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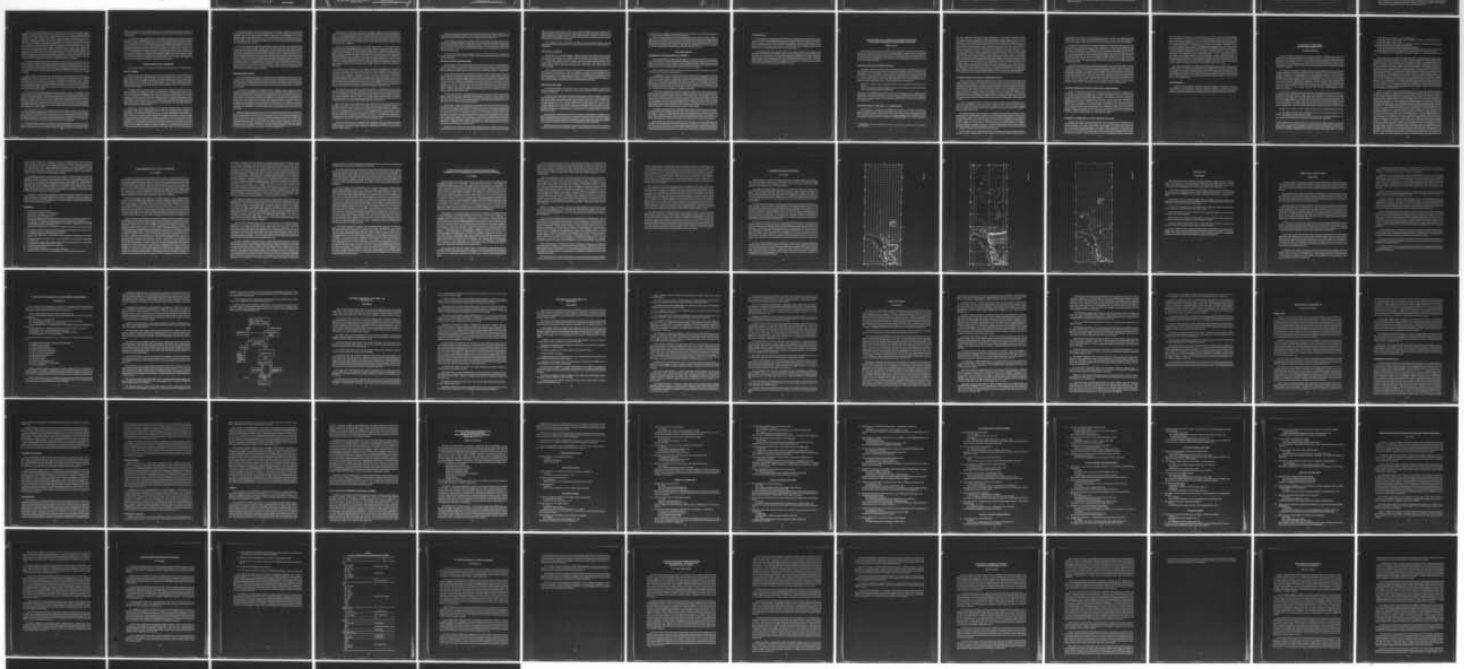

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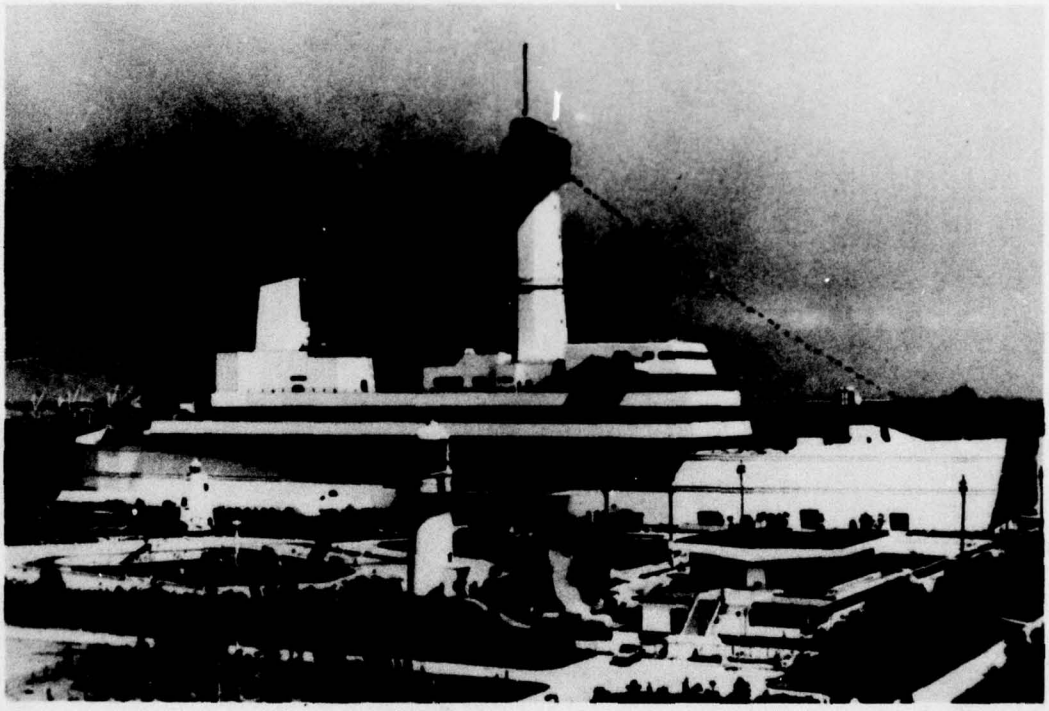

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This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR

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SAFETY FACTORS
KUROSHIO
SATELLITE
TRACKED DRIFTERS
METALLURGY
SOCIAL PSYCHOLOGY
MATERIALS
WELDING
ALLOYS
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FLUID MECHANICS
TURBULENCE
SHEAR LAYER
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HEAT AND MASS TRANSFER
FISH BEHAVIOR
STATISTICS
MULTIVARIATE ANALYSIS
MATERIALS RESEARCH
STRESS CORROSION CRACKING
STRATIFICATION
AQUARIUM
MARINE BIOLOGY
MARITIME SCIENCE AND EDUCATION
PSCYCHOLOGICAL TESTING

20. ABSTRACT (CONT.)

Tokyo, with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an articie covering his own work, considered to be of special interest.

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
SCIENTIFIC LIAISON GROUP
AMERICAN EMBASSY
APO SAN FRANCISCO 96503

With the approaching end of my tour of duty at ONR Tokyo comes the realization that this issue is the last one that I will edit. It has been a stimulating experience, a mixture of pleasant memories and minor frustrations, the latter largely forgotten. Perhaps best of all were the letters of encouragement and criticism which we received. There wasn't a single one which wasn't appreciated. Those who helped get the Bulletin on the road must be mentioned. We acknowledge the sterling efforts of Dick Imus and his staff at ONR Headquarters, Harold Grant, also at Headquarters, Eunice Mohri, who was invaluable and continues on as Associate Editor, Kyoko Nakazawa, whose patient handling of the manuscripts assured both rigor and readability, the talented artists who provided the covers, and finally, all of the contributors without whom nothing would have been possible. I wish my successor a happy publishing experience, which it must be with this team as his support.

Morton A. Bertin

MORTON A. BERTIN
Scientific Director

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THE COVER: A photograph of the Museum of Maritime Science, constructed on landfill in the Bay of Tokyo. An article describing the museum appears in this issue.

CONTENTS

STUDIES OF A-BOMB SURVIVORS IN HIROSHIMA AND NAGASAKI

V. P. Bond

On Hijiyama Hill near the center of the city of Hiroshima is a cluster of Quonset hut-type buildings housing the headquarters of the Radiation Effects Research Foundation (RERF), through which extensive studies are carried out on the survivors of the atomic bombings of Hiroshima and Nagasaki in August of 1945. The results of these studies are followed closely in the scientific communities of most countries of the world, and they provide a principal input in consideration of the early and late effects of ionizing radiations, particularly those from atomic weapons, on human populations. In this article something of the history and program of the organization is described, as well as recent organizational and programmatic developments.

In December 1945, a team of American and Japanese scientists commenced studies on the acute medical effects of atomic bomb exposure in surviving populations of Hiroshima and Nagasaki. A comprehensive summary of the findings of this Joint Commission was published and a recommendation was sent to the President of the United States urging that a long-range, continuing study for possible late radiation effects in the exposed survivors be conducted. Consequently, the Congress of the United States authorized the initiation of such a program in 1947, and delegated to the Atomic Energy Commission the responsibility to fund the program and to the National Academy of Sciences-National Research Council the responsibility to organize the Atomic Bomb Casualty Commission (ABCC). The following year the Japanese National Institute of Health (JNIH) joined the program and established branch laboratories within the ABCC in both Hiroshima and Nagasaki.

Thus it has been apparent since before the inception of the Atomic Bomb Casualty Commission, that the Japanese experience in Hiroshima and Nagasaki represents a unique source of quantitative information on the effects of radiation on man. It is everyone's strong hope that this experience should remain unique. Therefore, every effort has been and should be made to study these populations thoroughly for many years.

In recent years it was felt increasingly by both the Japanese and Americans that there should be more participation by the Japanese in determining the breadth and scope of the scientific program and conducting the research. Also, financial problems made it increasingly difficult for the Division of Biomedical and Environmental Research of the Atomic Energy Commission (the Energy Research and Development Administration and now part of the Department of Energy) to fund the studies at a level adequate to conduct the necessary scientific investigations. Financial problems were aggravated by inflation, the changing relative value of Japanese and American currencies, and the fact that the expanded mission of the ERDA introduced many new demands on a budget that was not increased to be commensurate with the broadened responsibilities.

As a result of these considerations, a series of discussions was initiated between Japanese and American officials, culminating with the signing of the Act of Endowment in Tokyo in February of 1975 and the beginning of operation of the Radiation Effects Research Foundation on 1 April 1975. RERF is organized as a non-profit Foundation under Japanese law and is under the cognizance of the Ministry of Health and Welfare for the Government of Japan. That Ministry provides the Japanese share of the required funds; funds from the United States in support of the Foundation's budget are supplied by Department of Energy.

Key to the spirit and operation of the new Foundation is the equal participation of the Japanese and Americans in the establishment of policy for the operation of and the financial support of this organization.

The Board of Directors has equal representation from Japan and the United States, as do the Scientific Councillors. The Scientific Councillors and the Board of Directors have worked in unison to take care of many of the problems posed by RERF, and the governments of both nations have given every indication of complete support for the new venture. Local scientific, medical and other organizations in Hiroshima and Nagasaki have given extensive support. The establishment of RERF represents the breaking of new ground, in that the organization is operated and financed on an equal basis by the two governments. Obviously, this has introduced real and potential problems. It is clear however that there is a real desire to see the Foundation succeed, and this spirit of accommodation appears to assure the success of the new venture.

The ABCC-RERF staff reached a peak strength in 1958 of more than 1,000 employees, over 95% of whom were Japanese. The current staff includes a total of about 570, of which about 50 are classified as professional individuals. Most financial support came from the United States until early in 1974, when the government of Japan agreed to provide more than one million dollars to tide the ABCC over a financial crisis. The current annual budget is about 3.2 billion yen (about $11,000,000), one-half of which is provided by each of the governments involved.

The daily business of the Foundation is conducted by a binational Board of permanent Directors consisting of H. Yamashita (Chairman), L. Allen (Vice Chairman), S. Finch (Chief of Research) and M. Takabe (Acting Chief of Medical Sociology). Long range scientific and administrative direction to the Foundation is derived from biannual meetings with the extramural Japanese and American members of a Scientific Council and the Board of Directors.

The primary objective of RERF, to determine the late effects of A-Bomb radiation exposure in the populations of Hiroshima and Nagasaki, is carried out through a series of interrelated programs. The purpose of the *Life Span Study* is to determine if there is a substantial difference in the cause of death or the duration of life in the exposed individuals, in comparison to those who were not exposed. This mortality study involves about 110,000 individuals who resided in Hiroshima and Nagasaki in 1950, with major representation of all exposure groups and their controls. The Adult Health Study is designed to determine the effects of radiation on the survivors of the A-Bombs in Hiroshima and Nagasaki, which is important not only from its research content, but as a service to the subjects themselves through the detection of disease and the referral of persons with any abnormalities to appropriate medical institutions for treatment. Virtually all of the most heavily exposed persons are regularly examined at RERF, providing reasonable assurance that any clinically-evident late radiation effects will be detected. The study involves 20,000 members of the Life Span Study sample, over 80% of whom cooperated completely and are examined individually on a biennial basis. The Pathology Program is designed to provide the most accurate information possible on causes of death and on the presence of pathological lesions that are not observable by clinical methods. A tumor and tissue registry is maintained. The Genetics Program is designed to determine whether or not any biological effects of parental radiation exposure can be determined in the first generation offspring of the exposed parents in Hiroshima and Nagasaki. Approximately 45,000 individuals have been selected from the first generation offspring of exposed and nonexposed parents for the evaluation. These studies include observations on mortality, growth and development, chromosomal abnormalities, and variations in protein structure. A number of other studies are done, including an extensive program of total body and specific organ radiation dose estimates. These studies are a necessary prerequisite for the accurate quantitative evaluation of biomedical findings.

All results of studies are prepared bilingually in Japanese and in English, and approximately 600 copies of the reports are distributed widely to government offices, research institutes and research workers within and outside Japan. In addition, the findings are made available internationally through publication of the results in Japanese and foreign medical journals. The reports in the open literature now exceed 1,000.

Extremely valuable positive results have been obtained; of equal importance has been the total absence of certain findings despite intensive studies to detect them. Although early effects (up to several months after exposure) are of considerable importance, late and genetic effects have received more attention and only these

will be described briefly here. Several late somatic effects have been identified; studies on genetic effects have been negative to date.

Small head size and mental retardation have been demonstrated in those exposed while in utero, limited virtually to fetuses within 18 weeks of conception. The minimal "effective dose" for small head size appears to be of the order of 10-10 rad; of the order of 50-99 rad appears to be required for mental retardation. Developmental defects may be inferred, although the contribution of nutritional deprivation itself is difficult to evaluate. Children under age six at the time of the Hiroshima bombing, and exposed to 100 plus rad, were approximately 3 to 5 centimeters shorter and correspondingly lighter in weight at age 18 than those exposed to less than 10 rad. Lenticular opacifications were observed in irradiated survivors; however, severe opacifications (cataracts) were observed in relatively few (total of about 20 cases), exposed in the higher dose ranges. Chromosomal aberrations in somatic cells have been well documented, and a strong relationship between exchange type chromosome aberrations and radiation dose has emerged. A near-linear dose-effect curve appears to pertain in Hiroshima; a curvilinear relationship, increasing slope with dose, appears to apply in Nagasaki. Radiation from the Nagasaki bomb consisted almost entirely of gamma rays, while that from the Hiroshima weapon consisted of gamma rays and a significant component of fast neutrons.

An increase in the incidence of different types of malignancy has been a striking finding in the exposed populations in Hiroshima and Nagasaki. An increase in the incidence of leukemia received early attention and was well documented by the mid-1950's. The latent period appears to be about three years, with a peak increase in incidence occurring some 5 to 10 years after exposure. All forms of leukemia were observed except the chronic lymphocytic form of the disease. The effect per unit radiation dose appears to be greater in Hiroshima in which neutron radiation exposure occurred, as opposed to Nagasaki in which exposure was due virtually entirely to gamma radiation. An increase in malignancy was observed later in other anatomical sites; all types of malignancies seen are those observed normally. A definite association between radiation and an increase in cancer rates has been established for the thyroid, the female breast and the lung. These types of cancer show a longer latent period than does leukemia. There is a suggested relationship between the degree of radiation exposure and an increase in cancer of the lung. Suggested but less definite relationships have also been seen between radiation exposure and stomach cancer, malignant lymphoma, hematologic disorders other than leukemia, and tumors of the salivary gland, esophagus, urinary tract, and other regions of the gastrointestinal tract.

From the studies on cancer induction, it has been possible to determine "risk coefficients" for different types of malignancy. For instance, the risk of leukemia induction by radiation, as determined from the Hiroshima-Nagasaki studies at high dose levels, can be expressed as approximately 1 additional leukemia death, per million persons exposed, per year of observation, per rad of exposure. The increase in cancer rate in the exposed versus nonexposed populations can be appreciated more easily by noting the percentage increase in deaths due to induced neoplasms of all sites. For instance, it has been estimated that in a population of approximately 285,000 survivors in 1950, about 500 deaths in excess of the normally-occurring 69,000 had occurred by 1974. This amounts to an increase of about seven-tenths of one per cent. This can be broken down further into an increase of about one-tenth of one per cent in those receiving less than 20 rad, and an increase of about three per cent in those who received 20 or more rad.

Among the more important negative findings to date are the absence of genetic effects in the F_1 generation even though a number of studies involving several different indices were carried out (still birth, weight at birth, sex ratio, malformations, neonatal and infantile death, cause of death, cytogenetic studies, and biochemical detection of mutations). The study included a sample involving 77,000 conceptions. These studies are not taken as proof that radiation produces no genetic effects in human beings, but only as an indication of the low probability of such effects. Extensive studies with non-human species indicate that radiation probably induces genetic changes in all living forms. The children of exposed individuals in both cities now are under intensive investigation for evidence of radiation-induced cytogenetic aberrations or increased variations in protein structure.

Infertility has not been observed as an effect of radiation, nor has there been accelerated aging (including cardiovascular disease) as a result of the exposure. There has been no increase in mortality other than that resulting from the induction of malignancy, and there has been no detectable sustained alteration in immunologic functions of the body.

Recent advances in electrophoretic techniques have made it possible to detect various genetically-determined biochemical variants in human populations. These highly sophisticated and very sensitive studies are now being carried out on a large F_1 population in Hiroshima and Nagasaki. Complete results are not expected to be available for another 5 to 10 years.

Although a wealth of data on early and late somatic effects and genetic effects of radiation have already been obtained from the RERF studies, maximum value of this enormous effort can be realized only if the studies continue in effect for a number of years. For this unique source to be used to the fullest, quantitative data on late effects must be obtained over the entire life span of those exposed. It is essential that every effort be made to attempt to determine, by the sophisticated methods presently being employed, if genetic effects can be detected and quantified.

While providing quantitative data on effects, the RERF studies also contribute much to relieving the concern of many exposed survivors over the possible development of a number of late radiation effects. Only through the extreme cooperation of the populations of both cities has it been possible to arrive at some scientifically valid conclusions concerning late radiation effects in man. Such extensive quantitative information is available nowhere else in the world. It is expected that the facts about radiation effects learned from the Hiroshima and Nagasaki experiences will contribute substantially to man's intelligent use of radiation in this nuclear age.

IOOC '77: INTERNATIONAL CONFERENCE ON "INTEGRATED OPTICS AND OPTICAL-FIBER COMMUNICATION"

Arthur A. Oliner

This international conference, held partly in Tokyo and partly in Osaka during the week of July 18, 1977, was a landmark conference in two different ways. First of all, it was the first international conference on this topic held in Japan, and, in a sense, it was the first intentionally international conference on this subject held anywhere, since the corresponding meetings held in the USA and in Europe could legitimately be viewed as regional gatherings despite certain participation in each from other parts of the world. In this context, private discussions by representatives of the various national cosponsoring agencies were held during the conference relating to future cooperation among these regional meetings; more will be said on this point below.

Second, for the non-Japanese attendees the conference represented a real opportunity to learn about Japanese research and technology in this field. A reasonably good idea of Japanese progress had been achievable previously from Japanese publications in US journals and Japanese presentations at other conferences, but most of the Japanese work is published in Japanese journals and is therefore rather inaccessible to most Westerners. This conference exposed the full scope of Japanese efforts in this field, and the impact was very impressive. During the conference, speakers from various countries described their tests of fiber optic communication systems; in addition, two site visits were arranged where local field experiments on optical fiber systems could be seen. The impression created was that Japan was well ahead of the rest of the world in the utilization and test of such systems. But the truly stunning news for Westerners was furnished by the Exhibition associated with the conference. Just about everyone was greatly impressed with what they saw for sale by Japanese companies. From the low-loss optical fibers themselves to mechanical devices for accurately splicing them, the lead time from research paper to commercial exploitation was remarkably short. More details on this point, together with some reasons for the success, are presented below.

There were 618 registrants at the conference, of which 143 were foreign, from 15 different countries. The papers, which were almost all of high quality, totalled 174, of which 103 were from Japan and 71 abroad. The rejection ratio for submitted papers was about 50%. The Japanese organizers were frankly pleasantly surprised and somewhat overwhelmed by the response to the call for papers. The Tokyo portion of the meeting was held in the Tosho Building in the Marunouchi district, and the meeting organizers had arranged for two fine large halls, in anticipation of two simultaneous sessions. In view of the unexpectedly large number of good papers submitted, however, three simultaneous sessions had to be scheduled, but only two good rooms were available. They made do with a third room located in the second basement, which was long and narrow and was poorly air-conditioned. A standing-room-only situation prevailed much of the time there while seats went empty in the other two rooms. I was sensitive to the inadequacies of this third room because it was my luck to both chair a session and present a paper there. Except for this organizational lapse, which was unanticipated and beyond the control of the organizers, the conference was very well arranged and well run.

The main portion of the conference consisted of a three-day meeting in Tokyo, at the location mentioned above, with three parallel sessions at all times. A concurrent equipment exhibition was held in the same building during the first two days. On the morning of the fourth day, a technical visit to the Shinjuku Power Station of the Tokyo Electric Power Company was arranged; after this site visit most of the attendees went by Shinkansen (the fast train) to the Senri Hankyu Hotel in Senri, one of Osaka's new suburban towns, this one located just north of Osaka. On Friday, the fifth day, a so-called Post Conference Meeting was held at the Senri

Hankyu Hotel; this meeting was concerned primarily with fabrication technology, and no parallel sessions were involved. On the last day, Saturday, two more site visits were held, one to a CATV experiment using optical fiber transmission at Higashi Ikoma and the other to the Kansai Electric Power Company, where an experiment on optical fiber data transmission, similar to that at the Shinjuku Power Station, is being conducted. A rather full meeting resulted, with the first three days being the most hectic.

Before describing the technical highlights of the conference, some brief background material is presented which it is hoped will be helpful to those who are not specialists in this field.

BACKGROUND

GENERAL

The key to all the excitement in this field is the recognition that it is extremely likely that in the not-distant future most communication systems, including the mundane telephone, will employ optical fiber transmission means. If this indeed occurs, widespread technological replacements of equipment will be required, and the commercial markets will involve, literally, billions of dollars.

Optical fibers possess many advantages. Because optical frequencies are so high, optical fibers possess very large inherent bandwidths, with the result that very many telephone or video signals may be transmitted along the same fiber. Next, since the optical fibers have such small diameters they are small in size and light in weight. Furthermore, and this is very important, they are free of electromagnetic interference from neighboring electronic systems. Also, they have extremely low loss, so that long spacings between repeaters are possible. Finally, the fibers are made of glass or fused quartz, basic ingredients which are plentiful, so that ultimately the fibers will be quite cheap.

It is interesting, and perhaps even ironic, that the first applications for fiber optic systems will not utilize the large available bandwidth (which was the original motivation), but instead will exploit other virtues of these fiber waveguides: very small size, very light weight, and, most important of all, immunity from electromagnetic interference. In this connection, the US military has taken the early lead, with data bus applications and retrofitting in ships and in aircraft. The fibers will replace heavy copper cables, with a consequent reduction in weight of more than 10 to 1, and they will be free from electromagnetic interference from other electrical systems present. As demonstrated in the two site visits at this conference, the Japanese are also taking advantage of this freedom from electromagnetic interference by running optical data transmission cables side by side with power transmission cables in the two electrical power stations we visited.

In view of the much smaller diameter of optical fiber cables, they can easily fit into existing underground conduits, which can be a significant advantage in crowded urban areas. It has even been speculated that the value of the copper being replaced by the fibers will exceed the eventual cost of the new equipment and the installation expenses.

Many other applications (besides telecommunications) are under serious study for optical fiber systems, such as computer system interconnections, process control systems, instrumentation in severe environments, certain types of data processing, etc. All in all, it is a very fast-moving technology with a very promising future.

TECHNICAL

A fiber optic system is basically quite simple, consisting of a suitable source of light, a modulator for imposing a signal on the optical carrier, then the fiber itself for transmitting the modulated light, and finally a detector which serves to transform the received modulated light into an electronic signal. The key to the spectacular success of the system lies in the fiber, so that it will be considered first.

As everyone in the field is keenly aware, there are three basic types of optical fiber: multimode step-index, graded-index, and single-mode step-index. These three types have been listed in order of increasing bandwidth capability. As their names indicate, step-index fibers contain a central "core" of slightly higher refractive index surrounded by a "cladding" of lower index; ordinarily, the fibers can support many modes simultaneously, but when the core diameter is sufficiently small, say about a half-dozen micrometers, the fiber will support only a single mode. The graded-index fibers (which are multimode) possess a refractive index that varies from the center to the outer radius in an approximately parabolic fashion, thus assuring waveguiding action. All types are surrounded by some kind of protective sheath. In broad terms, the multimode step-index fiber is narrow band, but it is easy to make and it is easy to splice. The graded-index fiber is capable of wider-band performance, and the splicing aspects are under control, but there are some manufacturing problems relating to fine control over the required refractive index profile. The single-mode fiber possesses the widest bandwidth capability and is easy to fabricate but, because of the small core diameter, a serious problem still exists in joining such fibers together with low loss. Since the bandwidth requirements of most communication systems are relatively low, the primary interest so far has been in the multimode step-index and the graded-index fibers, with stress on the former type when lower performance is acceptable and economy is paramount.

The concept of transmission by optical fiber waveguides has been around for a long time, but it became practical only since 1970 when the Corning Glass Company announced that they had produced a low-loss fiber made of glass which possessed a loss of about 20 dB/km for red light, whereas previous fiber losses were in excess of 250 dB/km. Since then, further improvements have been made by various laboratories in various countries, so that fibers can now be achieved with losses which are astoundingly low. The lowest values, reported at this conference, are about 0.5 dB/km, obtained with fused silica cores, and they are that low even for single-mode fibers.

These low values occur, of course, only at selected frequencies. With compound glasses, the frequency corresponding to minimum loss occurs at about 0.85 microns, whereas with fused silica cores an additional minimum, with an even lower value of loss, appears at a wavelength that varies between 1.0 and 1.6 microns. The minimum at 0.85 microns happens to correspond, fortuitously, to the wavelength for GaAs technology. Very good sources and detectors are presently available at that frequency, and the first fiber optic systems are being developed in that frequency range. Active research is presently being conducted on sources and detectors at the lower frequency range, for which the loss for silica fibers is even lower; the sources are coming along well, but good detectors are not yet available.

For systems with low performance requirements and with a stress on economy, GaAs LED (light emitting diode) sources are used together with multimode fibers and with PIN diodes serving as the detecting device. The LED's are incoherent and are hard to modulate at high speeds, but they are reliable. Semiconductor lasers utilizing GaAs and GaAl As technology offer much better performance, and substantial research has been conducted relating to optimizing the laser structures and their coupling to fibers. The principal problem has been the laser lifetime, but accelerated life tests reported at this conference indicate that the results are very promising. Silicon avalanche photodetectors seem to work very well at these semiconductor source wavelengths. Other types of solid state laser are under investigation for the lower frequency ranges, and the results so far seem promising, but suitable detectors are still a problem.

The comments above, and most of the commercial activity in this field so far, relate to fiber systems. We have not yet described integrated optics, which forms part of the title for this conference. Integrated optics refers to devices in planar form, rather than circular fiber form, which are fabricated on the surface of a suitable crystal, or substrate, usually electro-optic so that the optical wave can be influenced by dc or rf electric fields. It is ultimately expected that several devices will be fabricated and connected together on the same substrate—hence the term "integrated"—in analogy with integrated electronics at low frequencies.

The planar integrated-optical approach offers the way to perform sophisticated operations on the optical wave. At this stage, however, with the communications field interested primarily in low-data-rate systems, integrated optics has not been found necessary. The simpler processes required so far can be handled within

the fiber framework alone. For this reason, industry, except for those companies with large research laboratories, has done little on integrated-optical circuits. Many of the advances have been made by universities in various countries.

It is also true that integrated optics is suited most naturally to single-mode operation, whereas the simpler fiber systems operate in multimode fashion. It is, on the other hand, widely believed that when single-mode fibers will be employed, planar integrated-optical circuitry will be needed and will be called upon. The suitability of integrated optics in that context is based in part on the compatibility with single-mode fiber operation, but is also related to the fact that the wider bandwidth capability of the single-mode fiber will require more sophisticated multiplexing, switching, and other operations, which can be handled best via integrated optics. Even within telecommunications, then, it is expected that integrated optics will have its day. In addition, however, it is appreciated that the complexity inherent in integrated optics permits a variety of data-processing functions to be performed on a small chip, offering small size and weight combined with reliability and ruggedness. Although the needs are not yet manifest, the possibilities resident in such circuitry are sufficiently intriguing and promising that industry is beginning to eye integrated optics much more closely. It was learned at this conference that this attitude is currently being expressed by Japanese industry.

TECHNICAL HIGHLIGHTS OF THE MEETINGS

The conference consisted of two separate meetings plus site visits. These will be described separately.

KEYNOTE ADDRESS

The keynote address was sufficiently noteworthy to warrant special attention. It was a superb summary of the status of the field, and it contained reference to certain latest Japanese results in addition to the speaker's views on what still needs to be done. The address was particularly important because it was presented by Dr. Bunichi Oguchi, who is the highest-ranking technical person in NTT, the Nippon Telegraph and Telephone Public Corporation, which coordinates the telecommunications activities of many other Japanese companies. Dr. Oguchi's position is that of Senior Managing Director and Chief Engineer, and he is a specialist himself in fiber-optical communications.

Dr. Oguchi's address was entitled, "Light in Telecommunications–Present Status and Future Prospect," and it was basically very optimistic. In the talk, he made reference to several different field tests run by NTT since 1974, showing the continuing improvement in performance and the increasing distances between repeaters that have become possible. An 800 Mb/s system has recently achieved a repeater spacing of 7.3 km. He also examined the number of channels which could be handled by optical fiber cables and concluded that the flexibility inherent in the approach (from 10^2 to 10^6 channels) offers the possibility that fibers will replace all existing metallic conductor cables. He pointed out that in the main cities of Japan the existing underground facilities are extremely congested, so that replacement of existing cables by the much-smaller-diameter fiber cables would also be a boon on social grounds.

Among the new results of Japanese R&D, he cited the following. Accelerated life tests for semiconductor lasers (GaAl As-GaAs double heterostructure lasers) have shown very promising results; extrapolation to a temperature of 40°C indicates an average lifetime of 2.7×10^5 hours, which exceeds the value demanded by system designers. He concluded that ultimate laser lifetimes may become comparable to those for LED's, and that such lasers may well dominate the field. NTT has also successfully grown lithium neodymium tetraphosphate crystals, and such crystals oscillated continuously at wavelengths of 1.047 μm and 1.317 μm when using a semiconductor laser pump. Such sources are being explored for use with lower-loss silica fibers, of course. With respect to the fibers themselves, the chemical vapor deposition process for producing high purity silica has yielded fibers with remarkably low loss. He reported that the OH radical concentration was reduced to less than 50 ppb, so that a minimum transmission loss value of 0.47 dB/km at 1.2 μm wavelength was achieved for a multimode fiber, and a value close to that for a single-mode fiber. These values are near to the theoretical limit.

Dr. Oguchi indicated that in the near future systems with 32-100 Mb/s data rates will be used for short distance inter-city transmission and for inter-office trunk lines. After further experience has been obtained, long-distance digital trunk systems will be established; he expects them to play significant roles in a future integrated digital telecommunication network, which will handle video, data and facsimile, as well as ever-increasing telephone needs. Optical fibers are also expected to be introduced into submarine cable systems; shorter transmission circuits, connecting some islands, will be tried first, but he hopes that trans-oceanic applications will ultimately come to fruition.

The near-term problems which he feels must be solved include the following: more accurate dimensional control of the refractive index profile for graded-index fibers, more economical fiber manufacturing processes involving continuous pulling and higher drawing speeds, and better coupling and splicing methods for underground circuits. Dr. Oguchi ended his talk by listing several items for future research. Most important for him seemed to be the development of detectors and circuit components for the wavelength region around 1.3 μm, where exceptionally-low-loss fibers have been fabricated and where solid-state sources seem feasible. He pointed out that, if satisfactory components are available for this wavelength range, repeater spacings of 20 km become possible, or even up to 50 km for moderate data rates. He specified integrated-optical circuits as the next area for research, stressing that the guided wave approach should yield new technology which would permit us to control optical waves to a much greater extent. He recognized, however, that these efforts are in their early stages and that much research needs to be done. He finally listed on a slide, without further comment, all-optical repeaters (without the need for electronic amplification at lower frequencies) and optical applications to computers. There were no questions at the end of his talk.

THE MAIN MEETING IN TOKYO

As was indicated earlier, this portion of the conference involved three parallel sessions at all times, so that at the very best two-thirds of the talks had to be missed. In practice, I covered probably less than one-fourth of the talks, in view of valuable discussions in the halls and time spent at the Exhibition, which was held concurrently. The frustration resulting from having to miss so many talks was compensated in part by the availability of a rather complete and well-prepared Technical Digest of the papers. A post-deadline session was also held on Tuesday evening.

The coverage of the technical areas comprising the field was remarkably complete, ranging from new ideas decidedly in the early research stages to details of tests on systems. Although the area of integrated optics is primarily in the research stage, and there is as yet little commercial interest in it, it is interesting to note that about 40% of the papers related to or were identified with integrated optics. In this estimate, I am including papers on semi-conductor or other solid-state lasers, which were identified by the organizers with integrated optics even though they are being considered for use with fiber systems; if these laser papers are not included, the percentage on integrated optics drops to about 25%, which is still a significant proportion. In addition, the sessions on integrated optics were generally very well attended, often with standing room only. I asked some of the Japanese attendees why they listened to the integrated optics papers even though their own work was on fibers, and their replies were essentially that most of the new ideas were in the integrated optics areas, and they were eager for new ideas.

Before proceeding to the technical content itself, a few additional general remarks may be made. Most of the contributions were from Japanese researchers, as may be expected since the host country was Japan, but the extent and sophistication of their efforts were truly impressive. They covered the expected technological directions very systematically, but they also presented many papers containing innovations. It may be unfair to generalize with respect to the following characterization, but I found that the few papers at the conference with strongly independent approaches were by Westerners rather than by Japanese. Although there were contributions from a variety of countries, including surveys of national efforts, the only other country with a large and comprehensive program appeared to be the US. In connection with the exploitation and test of optical fiber systems, however, the Japanese seemed to be ahead of all others, including the US.

Several papers were presented by Russian authors, including a national survey of certain programs. In contrast to the extensive and innovative work done by the Russians on high power lasers, with application to fusion, etc., it was painfully apparent here that in this field the Russians are far far behind. The total effort is skimpy and the experimental results are inferior to everyone else's. In one talk, some theoretical results were presented regarding alternative refractive index profiles for multimode step-index fibers; in response to questions after the talk it emerged that no measurements had yet been made, and the important question of bending losses had not been considered.

In the area of integrated-optical circuitry, many papers were presented, covering the following topics: nonreciprocal effects using magnetic fields, use of anisotropic materials to provide mode filters, mode converters and modulators, tapered and chirped gratings for improved filters, investigations of nonlinear effects for second harmonic generation or sum frequency generation, many papers on strip-type three-dimensional waveguides, including a theoretical paper showing new leakage effects, applicational papers, and those describing fabrication techniques for such waveguides, a large amount of activity on different types of modulators and switches, including a traveling-wave structure to produce large modulation bandwidth, several structures using modifications of parallel strip waveguide directional couplers, and Brag deflection devices, a number of papers on hybrid or monolithic integration of components on the same substrate, and several papers involving novel ideas or schemes unrelated to communications. (One slide which caused me to chuckle read: a) Phase Match, b) Miss Match.)

On these topics, I was surprised to note the amount of activity on strip waveguides and on monolithic integration studies; there was more than I was led to believe on the basis of published literature. Certainly, most of the papers on integrated optics stressed potential application to telecommunications, even though the basic components could be applicable to other needs, but a few were openly not concerned with communications. Among these were a processor for multichannel data, which compares a set of signal voltages to a reference set, using novel holographic subtraction; the intended application is to multi-spectral scanners. Another involved waveguide lenses as part of an integrated system for Fourier transform signal processing. Then, there was a novel idea for creating a superconducting Josephson junction using a strip waveguide to provide the necessary weak link, and to thereby permit optical control of Josephson junctions. It is interesting that the above three papers, and some others unrelated to communications, came almost exclusively from Western countries.

There were, of course, many papers on sources and a few on detectors. Regarding detectors, those for the 0.85 μm wavelength range seem to be very satisfactory and ready for use in the field: Si avalanche photodiodes for better performance and Si PIN diodes when economy must be stressed. The newer work involves monolithic arrays of the photodiodes for multi-fiber application. The problem related to the lower frequency range, where lower losses are obtainable for silica core fibers. For that range Ge avalanche photodiodes have been developed, but they need further work, and ternary alloys, such as GaAsSb and InGaAs, are being studied. A novel ultrabroadband detector-mixer involving a thin-film MOM arrangement was also reported.

Of the various papers on semiconductor lasers, there were review surveys, papers on suppression of ringing, higher power output, life tests, such lasers in circular configuration, and the monolithic integration of a laser with an integrated optical circuit and a series of DFB lasers multiplexed through strip waveguides to a fiber. There was also work on the compensation of nonlinear distortions in LED's. The greater interest was expressed in the wavelength range from 1.0 to 1.3 μm. There, GaInAsP/InP diodes, reported previously by Lincoln Laboratory, work well and have shown lifetimes exceeding 2000 hours. The Japanese also reported work on lasers and LED's using that material. Also promising for this range is a class of solid-state miniaturized Nd-compound lasers that can be efficiently pumped and have low thresholds. The Japanese are actively working on a promising variant, namely LNP, as reported by Dr. Oguchi in his keynote address.

Some work was reported on fiber transmission effects and passive circuitry. There were studies on mode-coupling effects and pulse broadening in graded-index fibers, launching and coupling loss studies for such fibers, and fiber couplers, in an attempt to achieve coupling and multiplexing directly with fibers, without requiring integrated-optical technology.

Many papers were presented on the practical data needed for fiber system evaluation. Included were such topics as the loss and dispersion properties of fibers, tensile strength, fiber break angle, new splicing methods, coupling between LED's and fibers, and methods for measuring the refractive index profiles.

Systems utilizing optical fibers were described, including TV transmission, data links, and optical instrumentation. Also presented were details on many field tests, in various countries. One which merits special note is that undertaken in Japan by NTT at a wavelength of 1.05 μm. It used a very low loss (0.75 dB/km) single-mode fiber, an LNP laser, a $LiNbO_3$ integrated-optical modulator, and a Ge avalanche photodiode detector. Many problems were encountered, but the results were encouraging; this field test represents a very good start in this new wavelength range.

A number of survey papers were presented on the status of work in this field in various countries; the countries were Japan (actually only NTT), UK, USSR, Germany, France, Australia, Canada and the US (actually only the Bell System).

THE POST CONFERENCE MEETING IN OSAKA

This one-day post conference meeting consisted only of invited papers, and was devoted to different phases of fabrication technology, a most important aspect of this field where proper fabrication methods spell the difference between success and failure, both in performance and in economic terms. Three of the four sessions related to technology for integrated optics; the fourth was concerned with fibers composed of compound glasses.

The first session summarized various methods for producing the required complex geometric circuit on a film on a substrate. The four papers explored grooving techniques, ion beam etching, chemical etching and plasma etching. The second session continued this theme. The first paper described diffusion techniques for producing embedded strip waveguides in $LiNbO_3$ and $LiTaO_3$, and the second considered various photolithographic fabrication processes for producing strip waveguides and waveguide couplers with smooth edges and good dimensional control. The last two papers dealt with amorphous chalcogenide films. In the first of the two, photolithographic techniques were discussed based on the photostructural changes which occur with these films, and selective etching was used to produce gratings. The second paper described how gratings were produced by directly "writing" on these films with a scanning electron microscope; a resist is not needed since a directly-induced refractive-index increase is produced.

The third session was devoted to epitaxial growth methods. The six papers in the session presented various aspects of molecular beam epitaxy, liquid phase epitaxy and vapor phase epitaxy, and then a panel group discussed the merits and deficiencies of each method. It emerged rather quickly that the panelists did not, in the main, agree with each other. The paper by Texas Instruments on liquid phase epitaxy presented some impressively fine results on I bar lasers with seemingly perfect edges.

The last session, on fabrication technology for compound glass fibers, offered a lesson in how technology, economics and patent problems can become intertwined. Even with the best performance to date for these fibers (the Japanese obtained a minimum loss of 4.23 dB/km, just easing out the British who got slightly over 5), they are substantially lossier than the silica core fibers. It is evidently difficult to remove the OH radical and the impurities. Furthermore, the minimum in attenuation occurs in the 0.85 μm wavelength region, making these glass fibers suitable only for GaAs technology; they do not possess the lower minimum at lower frequencies. After some discussion at the end of the session, it was predicted that the minimum loss would eventually drop to slightly under 3 dB/km, a value which is still about twice the loss value silica core fibers currently have at that same wavelength. In addition, during the whole discussion no mention was made of the silica core fiber technology; it was completely ignored. Why does this diligent effort regarding compound glass fibers proceed while ignoring the silica fibers, and, indeed, why at all?

The answer involves the facts that these compound glass fibers do have certain advantages (and other disadvantages), and that a complex patent situation exists regarding the silica core fibers but not the compound

glass ones. The compound glass fibers do have poorer mechanical strength, but they can be fabricated more easily and cheaply, by using a double crucible process that permits continuous fiber pulling, rather than requiring batch processing. In addition, they have a lower melting temperature, resulting in energy saving, and greater flexibility in characteristics. In short, they have their place: poorer performance, but more economically fabricated and without patent complications.

As an interesting side note, a closed-circuit TV system was set up for those who wished to watch the presentations in the more comfortable lobby area; an optical fiber system was used in the implementation, and it worked well.

THE TECHNICAL EXHIBITION

As mentioned above, a technical exhibition was held concurrently with the technical sessions during the first two days of the conference. Only Japanese companies participated in the exhibition, but 23 companies were officially involved, ranging from the giants, such as Fujitsu, Hitachi, NEC, Sumitomo, Mitsubishi, OKI, etc., to small trading companies. The exhibits themselves covered the range from promising complete systems of various kinds, through all types of fibers and fiber cables, and all kinds of devices such as lasers, LED's, optical attenuators, couplers, multiplexers, measuring sets, etc., down to fiber cutters, splicers, strippers, and micro-manipulators.

In part, the range of products offered was certainly impressive, but what was really stunning was the very short lead time from research paper to commercial exploitation. For example, a novel fiber-splicing method, in which the fiber ends are butted under pressure and heated and accurate alignment is then produced by surface tension, was presented as a post-deadline paper last February at the OSA Topical Meeting in Williamsburg, Va. Now, equipment based on this method is available for purchase. It was clear that the Japanese are making a systematic commercial assault on this field, with its multi-billion dollar ultimate potential.

THE TECHNICAL SITE VISITS

The experiments shown at the site visits were of two types: first, data transmission via optical fiber at electric power stations in Tokyo and Osaka, and, second, the use of optical fibers for TV transmission and distribution in the Osaka area.

The electric power companies have been becoming increasingly concerned about failures in their power systems and the need for a new system to detect them. Ordinary cable systems are not sufficiently reliable because they suffer from electromagnetic interference, which is actually worse at the occurrence of failure in view of the electrical surges which occur. Fiber optic systems are ideal for this purpose because they are free of electromagnetic interference, are easy to install, and have a large data-carrying capacity. Test systems have therefore been established, and we were shown the arrangements at the Shinjuku power station of the Tokyo Electric Power Company and at an Osaka location of the Kansai Electric Power Company. Details were presented regarding the intra-station and inter-station systems. These tests have been going successfully for over a year, and more are planned.

The second type of field experiment, involving TV transmission, is called Hi-OVIS, for Higashi Ikoma Optical Visual Information System. In this system, the incoming TV signal is received on a nearby mountain top (Ikoma mountain), and then transmitted by optical cable to a central station located 3.8 km away, in Higashi Ikoma, a new town constructed east of Ikoma, in Nara prefecture, near Osaka. The program is then distributed to 168 subscribers. This system is claimed to be the first optical subscriber system in the world.

These subscribers do not pay anything for programs or other information received, but they cooperate by providing data and answering questionnaires; the total cost, about $20 million over four years, is to be borne by

the government. Three companies are participating in the project: Sumitomo for the Optical System, Fujitsu for the Control Computer, and Malsushita for the Video equipment.

The optical system employs a silica core step-index multimode fiber, with a loss of about 5 dB/km, an LED source, and a PIN diode detector. The optical wavelength is 0.82μm. What was most intriguing was the claim that the system operates in a passive fashion, so that the LED does not require a power supply. The video pulse triggers (and therefore modulates) the LED, which then sends an optical pulse down the low-loss fiber; the PIN diode at the receiving end then recreates the video pulse. The optical fiber link has not yet been constructed, but the experiment will be completed about a year after everything is connected.

CONCLUDING REMARKS

ASSESSMENT OF JAPANESE METHODS AND ATTITUDES

After seeing the Exhibition associated with the conference, an attendee from Western Europe remarked to me, "The West will do the research and the Japanese will capture the commercial markets." The statement illuminates some elemental truths even though it is a gross oversimplification and an unfair distortion. It is unfair because it was clear from the papers presented that the Japanese have conducted a great amount of research in this field, and that much of it was innovative, let alone in the forefront of the field.

On the other hand, certain Japanese methods and attitudes lend credence to the statement. Two of them which seem most relevant to me are mentioned now.

1. Throughout their history, the Japanese have freely adopted what they felt was good in other countries; they then modified, often in completely novel ways, what was taken, and they subsequently incorporated it into their own culture. Examples are furnished by painting styles and Buddhist religious ideas taken from the Chinese, and technology learned from the West after Japan was opened up to the West during the 19th century. With respect to recent science and technology, this attitude leads the Japanese to systematically read the published scientific literature from other countries and to try to adapt those methods as soon as possible. The origin of the idea does not influence their use of it—only whether or not the idea has merit. They are not hindered by the "not invented here" factor that inhibits many engineers in US industry.

2. There exists overall government support and planning of industrial efforts, a feature which in part becomes possible because Japanese industrial concerns cooperate well with each other. The cooperation between NTT and industry in general seems well orchestrated, with funds coming largely from MITI (Ministry of International Trade and Industry). For example, with respect to optical fiber research and development, three cable companies have contracts with NTT; the companies are Sumitomo, Furukawa and Fujikura. Specific responsibilities were assigned, with some overlap, and a schedule has been established; the stress last year was on multimode step-index fibers, this year on graded-index fibers, and next year on single-mode fibers. This type of planning probably explains why the research conducted by the Japanese generally seems to be closer to a direct performance problem or a commercial need than does the research in other countries.

In my opinion, the above-mentioned free-wheeling attitude toward ideas, together with the well-orchestrated and supported industrial planning, permit the Japanese their impressive ability to reduce ideas to practice so successfully in so short a time. Despite this evident success, many Japanese researchers profess to have an inferiority complex regarding the collective Japanese research ability, although they attach no embarrassment to it. They feel that the principal expertise is abroad because their experience is limited; their success is only of recent vintage, whereas Westerners, particularly the US, have been the research leaders in this field for a generation.

Although MITI's financial support coordinates the NTT and industry work on optical fiber systems, this coordination must operate within a framework in which most of the patents are owned by the US. The Japanese feel, on the other hand, that the next big phase will involve integrated optics, for which there is still much to be done and for which few patents exist so far. MITI is therefore seriously considering substantial support for industrial research on integrated optics so that Japan can get its own patents in this area before the US does.

FUTURE MEETINGS

It was mentioned at the beginning of this report that various regional meetings in this field may in the future be coordinated. The regional meeting in Europe is the European Conference on Optical Communication, which is held every other year. The last meeting took place in Munich, Germany, from September 14-16, 1977. In the US, the Optical Society of America sponsors Topical Meetings on optical fibers and on integrated optics separately, each held every other year. The one on optical fibers was last held in Williamsburg, Va., this past February; the one on integrated optics will be held January in Salt Lake City.

Various suggestions have been made. One is that the next European meeting, already scheduled for Amsterdam in 1979, be termed the second IOOC, thereby in essence combining the European and Japanese efforts. The US has been invited to join, but in principle this would require combining the two separate Topical Meetings which now exist. Another proposal is that all the regional meetings continue as now, with a corresponding Japanese regional meeting, but that every three years or so a huge international meeting be held. The various national committees will separately explore these suggestions; some decision may emerge from the 3rd European Conference on Optical Communication, held in Munich in September.

SOME MATHEMATICAL ASPECTS OF ENGINEERING RESEARCH AT SELECTED UNIVERSITIES IN HONG KONG AND JAPAN

Jeffrey T. Fong

The convening of two international conferences in Asia, separated by a three-week interval, provided me recently with an opportunity to report on certain mathematical aspects of engineering research in Hong Kong and Japan. Since my first academic degree was earned at the University of Hong Kong twenty-two years ago, I had very little problem in renewing my contacts with research workers during my three-week stay there. For my ten-day stay in Japan, I was fortunate to have the assistance of a friend and colleague who is presently a member of the scientific staff of ONR Tokyo.

TWO SPECIFIC TOPICS OF ENGINEERING RESEARCH

My personal experience has taught me that unless I deliberately sharpen my inquisitive aims at the beginning of a business trip, by the time I am ready to come home my mind will be completely saturated with interesting, highly coupled but disorganized information on people, data, equipment, theorems, and controversial interpretations of new results. Therefore, for this trip I chose two specific questions in materials research which are currently of considerable interest both to my laboratory, the National Bureau of Standards, and to a segment of the technical community in the United States with which I interact through American Society of Mechanical Engineers and American Society for Testing and Materials. The two questions are:

> How does one quantify so-called "engineering judgment" in the conventional use of safety factors in design?
> How does one quantify mathematical judgment in the use of lower-dimensional solutions as approximations to higher-dimensional problems in engineering?

Clearly there are strong mathematical components to each of the two questions, and it was with those mathematical aspects in mind that I embarked on a month-long trip to Hong Kong and Japan where I visited five research centers and attended two international conferences. (International Conference on Fracture Mechanics and Technology, Hong Kong, March 21-25, and Third International Conference on Pressure Vessel Technology, Tokyo, April 19-22.)*

STATISTICAL MODELS "IN THE LARGE" FOR ASSESSING SAFETY

Engineering design, by and large, may be thought of as an optimization process which, in principle, requires the formulation of an extremely complicated objective function over cost, safety, and some clearly defined performance parameters. To ensure that a design will be done properly, the engineering community relies on published handbooks, codes and standards, and engineering judgment based on experience from past performances of existing products. It is the last item, the engineering judgment, that is usually found deficient

*(Editorial Note: The Hong Kong meeting was reviewed in the previous issue of this bulletin and the Tokyo meeting is reviewed in this issue.)

in a "faulty" design. By tradition the safety factor concept has been used by engineers to translate their judgment into a single number accounting for a multitude of variabilities not anticipated in the design. For instance, the variability of material composition of quality of shop fabrication and field installation, and of service load fluctuations is commonly handled in this way. In a departure from the traditional way of design based on handbooks and safety factors, research workers in both the United States and abroad have recently recognized the need to formulate statistical models as a means of enriching the data base of experience on critical structures. Professor Peter Lumb of the University of Hong Kong has successfully pioneered a step-by-step introduction of statistical concepts into the design of structures on soils—the variabilities in soil properties and loads are among the worst in engineering. Two concepts are significant and worth mentioning: (a) while for preliminary design no great precision is required, some indication of the sensitivity of the response to many of the variables is needed. Professor Lumb outlines a scheme to calculate approximate means and variances of those variables judged to be important. As a way of ranking different proposed designs, he then used the Central Limit Theorem to determine the failure probabilities. (b) For final design, Professor Lumb recommends a design procedure involving two possible limiting cases, one case for which population variances control the design and the other for which variances of the mean control the design. Which limit is actually closer to the truth can only be determined by physical reasoning based on soil behavior and augmented, wherever possible, by field observations. In a published numerical example he has shown that since the estimated probabilities by the two methods have large differences, in practice it will always be important to decide which limit should be used. The mathematical aspects of Professor Lumb's work are particularly valuable because they are general enough for application to other critical structures such as pressure vessels, piping, nuclear reactor components, and aircraft structures.

STATISTICAL MODELS "IN THE SMALL" FOR IMPROVING SAFETY

With the development of sophisticated diagnostic tools such as electron microscopy and ultrasonic image analysis, engineers and material scientists have been conducting both theoretical and experimental research with the long-term goal of predicting the mechanical properties and residual strengths of structural materials from measurable microscopic parameters. Statistical tools are again indispensable for bridging the gap between microscopic observations and macroscopic phenomena. Progress in this type of research contributes to an enhanced level of structural safety because through the results a number of safety factors on material parameters, such as fatigue life and fracture toughness, can acquire a statistical interpretation compatible with the approach outlined by Lumb. Since we are dealing with microscopic quantities, we shall refer to this type of work as statistical modeling "in the small." It is gratifying to report that there are many research groups in Japan active in this area. Five groups that I visited are particularly energetic here and their contributions may be briefly summarized as follows:

(a) Dr. H. Fukuda and Professor K. Kawata at the Institute of Space and Aeronautical Science, University of Tokyo, discussed their work on the estimate of Young's modulus of short fiber-reinforced composite material of constant fiber length and random orientation. Taking account of a number of simplifying assumptions, the model agreed reasonably well with some experimental data, whereas the classical rule of mixture is shown to be off by a factor of two.

(b) Professor Kitagawa and his co-workers at the Institute of Industrial Science, University of Tokyo, discussed their work at his laboratory. Beyond that, he and his students presented papers at the two international conferences which I attended on this trip. In both papers Professor Kitagawa assumed a four-parameter probability density function to represent the distribution of pre-existing crack lengths in a given specimen or an actual component. He further uses a homogeneity function due to Kawarada, Masuko, and Yanagida (J. Faculty of Engrg., Univ. of Tokyo (B), **31**, 715 (1972)) and a number of crack interaction and propagation hypotheses to simulate coalescence of cracks and to estimate failure probability based on fracture mechanics. The work is significant because it demonstrates the usefulness of a statistical model "in the small" for estimating the reliability of structures under periodic nondestructive inspection.

(c) The research of Dr. Y. Haguida and Professor M. Matsunaga at the Institute of Industrial Science, University of Tokyo, complements that of Professor Kitagawa in the sense that whereas Kitagawa models the

strength behavior of specimens with crack lengths varying from 50 μm ± to about 20 mm, Haguida and Matsunaga have found a way to measure crack size distributions between 5 μm and 70 μm. This work is significant because it sheds new light on fatigue mechanisms in the gap between dislocation theory and fracture mechanics.

(d) Professor T. Kawasaki and Dr. Y. Sawaki at the Department of Mechanical Engineering, Tohoku University, Sendai, are about one hour away from Tokyo by jet aircraft. In their early work (published in 1972) they used a counting algorithm due to Fullman (Trans. AIME, Vol. 197, p. 447 (1953)) to estimate manually two microstructural parameters from representative electron micrographs of two high-tensile steels, two low alloy steels, and one carbon steel. The two microstructural parameters are the mean size of carbide particles and the mean free spacing between carbide particles and grain boundaries. Even with an incomplete treatment of their data by statistical tools, they are able to conclude that the fatigue strength of steels is much more structure sensitive than the static strength. This result is significant because it contributes to a growing trend of using "quantitative microscopy" and statistical analysis as new tools for quality control and strength estimation of structural-grade materials.

(e) Tohoku University at Sendai is among the most prestigious centers of learning in Japan. For me the main attraction was the Research Institute for Strength and Fracture of Materials founded in 1964 by Professor T. Yokobori. As early as 1952 Professor Yokobori began publishing his statistical model "in the small" by treating various phenomena such as yielding, ultimate strength, brittle fracture, and the brittle-ductile transition temperature, essentially all as a Markov process of nucleation. Since then Yokobori and his co-workers have extended their stochastic theory to solids with a finite number of distributed cracks of nominally fixed size. To verify their theoretical result, numerical experiments using the Monte Carlo method were conducted on a computer. Professor Yokobori's work is significant because it provides a statistical basis for important critical phenomena such as yielding, fatigue, and fracture. The characteristic length of interest in Yokobori's theory varies from ~100 Å to about 20 μm, making it a natural complement to Professor Matsunaga's work.

STATISTICAL MODELING OF FATIGUE AND FRACTURE–A BIASED SUMMARY

By now, the reader should sense some of my views on the concept of safety factors. Hopefully, I have demonstrated my belief that there are four levels of statistical models ranging from the very small (Yokobori, et al) through the moderately small (Matsunaga, et al) and the small (Kitagawa, et al, Fukuda and Kawata) to the large scale (Lump). Structural failure invariably begins at the level of the very small, but designers must necessarily work with macroscopic dimensions and service loads at the large scale level. A rational basis for assigning safety factors cannot be constructed without a rigorous connection among all four of these levels of statistical models. I am happy to report that some research of a comparable nature is also being carried out at various places in the United States, at the National Bureau of Standards for instance. What is most gratifying to me as a result of this trip is the discovery that concern for a rational basis for safety factors seems to know no national boundaries. It is my biased conclusion that in the next decade the field of statistical modeling of the phenomena of fatigue and fracture will receive a great deal more attention than it has in the past and, if I am correct, the researchers of Hong Kong and Japan will be among the vanguard.

MATHEMATICAL MODELS FOR MULTI-AXIAL FRACTURE AND FATIGUE

I shall now very briefly touch upon the second topic, namely, the assessment of lower-dimensional solutions as limiting cases of higher-dimensional problems. The need for such an assessment is nowhere greater than in fracture mechanics where a crack is seldom nicely situated and aligned for a two-dimensional analysis. This is a problem to which I am particularly sensitive because, while recently responding to a request for an assessment of girth welds in the Trans-Alaska Pipeline, my colleagues and I at the National Bureau of Standards found that most of the weld defects were neither shallow nor deep circumferential part-through geometric objects, but somewhere in between. To analyze these defects we needed three-dimensional solutions of elastic-plastic

material containing a part-through crack which unfortunately are very hard to come by. Shah and Kobayashi have shown that, even for a purely elastic solution of a moderately deep surface crack in a flat plate (crack depth to plate thickness ranging from 0.1 to 0.5), differences among various approximation schemes for calculating the stress intensity magnification factor may be as large as 50%. (The Surface Crack: Physical Problems and Computational Solutions, J. L. Swedlow, ed., pp. 79-124. New York: ASME (1972)) Professor H. Miyamoto of the University of Tokyo has done a three-dimensional finite-element solution of an elastic plate that should resolve this mathematical controversy on numerical schemes. (High Speed Computing of Elastic Structures, Proc. IUTAM Symp., Liege, Aug. 23-28, 1970, Vol. 61, pp. 137-155. Universite de Liege (1971)). Still, as observed by Knott in Fundamentals of Fracture Mechanics, "the present theory of fractural mechanics is based largely on the limiting states of plane stress and plane strain . . . ," and ". . . in principle, the finite element method can be extended directly to cope with such problems" (i.e., those problems requiring the consideration of an extra dimension in the geometry). As it turned out, Professor H. Miyamoto was available in both Hong Kong and Tokyo where the two international conferences were held. I took advantage of the opportunity to discuss with him our interest in seeing a continuation of his work for an elastic-plastic medium and we have agreed to exchange any new results on this interesting problem as they emerge.

The mathematical modeling of the phenomena of multi-axial fatigue or fatigue-creep interaction has been of interest to me for some time. It is not appropriate here to expand further on the subject of research at NBS but I am happy to report that I was able to discuss our recent progress on this subject with Professors Yokobori and Kitagawa and to consider the complementary aspects of our various programs. We are in agreement that probably within the next decade, as more experimental data become available, we expect finally to see the day when the macroscopic problem of characterizing the multi-axial mechanical properties of at least a smooth specimen can be completely solved.

ACKNOWLEDGMENT

I wish to take this opportunity to thank all the people whose names were mentioned in this article for their hospitality and technical assistance. In addition, I would like to thank Dr. A. T. Yokobori, Jr., of Tohoku University, whose help was critical when my flight from Sendai was cancelled, and also Dr. Elliot Kearsley, a colleague temporarily with ONR/Tokyo, whose timely guidance made manifest the importance of that office.

TUNNELING AS A MECHANISM FOR THE KAPITZA RESISTANCE*

Tsuneyoshi Nakayama

The heat transfer between liquid helium and a solid body produces a temperature discontinuity at the interface of the two media. This phenomenon, which may be considered as a thermal boundary resistance, was first discovered for liquid ^{4}He by Kapitza in 1941. The Kapitza resistance has important technical implications particularly at low temperatures. In 1957, Lee and Fairbank observed similar behavior for liquid ^{3}He, which served to prove that the boundary resistance was not peculiar to superfluid ^{4}He. Indeed, thermal boundary resistances have by now been reported for the interface between dissimilar solids at low temperatures including solid ^{3}He, H_2, D_2 and Ne.

The heat current to the surface is by phonons when a solid is non-magnetic and in this case the Kapitza resistance presumably must measure the efficiency of phonon transmission from the solid into excitations of the helium. Khalatnikov[3] and independently Mazo[4] have developed a theory based on the idea that thermal exchange is by phonons, but that these phonons have a high probability of reflection at the interface due to the large acoustic mismatch, $\rho_L v_L/\rho_S v_S$, between a solid and liquid. Here ρ_L, ρ_S, v_L and v_S are the densities and phonon velocities in the liquid and solid, respectively. This theory, the so-called acoustic mismatch (AM) theory, predicts a boundary resistance R_K proportional to the inverse third power of the temperature above about 1 K[5], however, the observed boundary resistance R_K is one or two orders of magnitude smaller than the theory predicts. Below about 0.1 K the AM theory is normally applicable if allowance is made for phonon damping in a solid due to surface roughness or defects[6]. Above 0.1 K there is general disagreement with all aspects of the AM theory.

In recent years, considerable progress has been made in understanding the heat transfer between solids and quantum media through the direct measurement of phonon transmission or reflection by the heat pulse technique[7-10]. Experiments[7] show that energy transfer is just as effective in a few atomic layers as it is bulk liquid. This strongly suggests that the first few layers of the adsorbed helium atoms are all important in the heat transfer. Equally significant is the evidence that phonon absorption is also anomalously large for solid H_2 or D_2 above about 1 K but that the heat transfer to solid Ne may be accounted for readily by the AM theory[8]. The similarity of the results for liquid and solid He, solid H_2 and D_2 seems to imply that the unknown mechanism which causes the anomalous energy transfer is the same in all of these "quantum" media.

Summing up the situation, we need a consistent explanation of the following experimental features:

(1) The unknown mechanism must be relatively weakly influenced by the physical condition of the interface[5]. This implies that the mechanism is a local event.

(2) With increasing frequency above about 20 GHz, phonons have an increasing probability of transferring energy across the interface and transmission is essentially temperature independent[9].

*Note: At the recent Sixth International Conference on Internal Friction and Ultrasonic Attenuation in Solids held in Tokyo in July 1977, I was particularly excited by a paper which seemed to solve an important problem in low temperature physics of 35 years' standing. In answer to my inquiries, the author of that paper, Dr. Tsuneyoshi Nakayama, sent me a letter outlining the work in simplified terms and giving some of the background. I thought that letter so clearly written that with the author's permission I am sharing it (in slightly edited form) with the readers of the *ONR Tokyo Scientific Bulletin*.–E. A. Kearsley

(3) The first few adsorbed layers of He play a significant role[7].

(4) The mechanism must be applicable to liquid or gaseous ^{3}He or ^{4}He, or to solid ^{3}He, ^{4}He, H_2 or D_2, but not to solid Ne or other 'ordinary' solids[8].

(5) We must explain why the anomalous heat transfer appears above 0.1 K and the anomalous absorption of quasi-monochromatic phonons occurs above about 20 GHz[9].

(6) The mechanism must inject phonons into the He at all angles[10].

(7) The transverse phonons are absorbed effectively by the quantum system[8, 11]. This is not consistent with the AM theory because of the mode-conservation in transferring phonons from a solid to the liquid.

(8) The mechanism must be independent of the quantum statistics, i.e., it must work for either ^{3}He or ^{4}He.

In the past there have been roughly three different approaches to explain the anomalous resistance above 0.1K. Since the AM mechanism seems to be present, it has been proposed that the AM model need only be modified. For instance, one such suggestion is that the dense layer of helium at the boundary (due to van der Waals' forces) serves to match the two acoustic media and thereby enhances the transmission of phonons[12]. However it is unlikely this method can explain the anomalously small R_K of He and H_2 and at the same time the normal R_K for Ne. The second approach, which is again being revived, is an explanation based on the absorption of a phonon at the interface and the consequent evaporation of a helium atom out of the dense van der Waals' layer into the liquid[13]. Such theories were the earliest attempt from a microscopic viewpoint. They predicted the AM limit at low temperatures and a value below that limit for higher temperature. However, this theory is dependent on the quantum statistics (^{3}He or ^{4}He). Furthermore, it has been pointed out that the poor agreement with the results for solid helium and solid H_2, or D_2 probably rules out this evaporation mechanism[14]. The third approach assumes the presence of extra-vibrational states close to the interface, a mechanical resonance[15] and a resonance mode[7, 16] of adsorbed impurities. The motional states of these layers are treated like that of phonons with defects. However, this idea is also applicable to the case of ordinary solids such as neon. We must note that the resonance mode appears in the impurities of heavy mass rather than the light "quantum" atoms. In summary, the underlying mechanism of the anomalous resistance above 0.1 K does not seem to be among these three approaches.

Recently, in a paper[17] presented at the ICIFUAS-6 held in Tokyo[17], the author proposed a new mechanism. This new mechanism can consistently explain the eight experimental features mentioned above. The theory is independent of the quantum statistics (that is, it works for ^{4}He or ^{3}He) and is also applicable to solid He or H_2. The anomalous temperature dependence is explained fairly well above about 0.1 K. The main hypothesis of the theory is that a number of vacancies or voids are contained in the first few adsorbed layers because of the misfit in these layers with the atomic arrangement of a solid. The presence of vacancies or voids means that tunneling (corresponding to two or more neighbouring equilibrium positions) can occur naturally in the helium atom layer close to the boundary. From this hypothesis, the author calculated the thermal resistance R_K using a one parameter fit and obtained excellent agreement with the experimental data. Of particular significance is the fact that it is possible to explain all the strange features of experiments ((1) - (8)) with this theory. For the interaction between phonons in a solid and the helium atom at the tunneling site, I took a displacement type interaction Hamiltonian, by expanding the interaction potential due to the van der Waals' forces between an atom in the solid and a helium atom in terms of the displacement $u_z(x, t)$ about the equilibrium position. For the interaction between tunneling states and phonons in liquid helium, I considered a deformation type interaction Hamiltonian. Any strain field e_{ij} of the environment of the movable helium atoms caused by phonons results in a modification of the asymmetry of the tunneling states, the distance between the two local minima, and the barrier height of the double well potential. Taking suitable values of mass, barrier height and tunneling distance we can roughly estimate the acceptable range of the energy distribution of tunneling states. If we take the potential wells to be identical the minimum energy difference E_{min} due to the overlapping of the wave functions is obtained. Using the mass of the helium atom with the high potential barrier height V~10 K between wells (which should correspond to the desorption energy of the second atomic layer) and a separation of 1 A, the minimum energy difference E_{min} is about 0.5 K, taking a zero point energy $\hbar\omega_0 = 1.5 \times 10^{-4}$ eV. This energy difference is extremely sensitive to the exact value chosen for these parameters, but as we have chosen the possible mass together with a high potential barrier height, the contributing energy distribution n(E) has some

acceptable range between $E_{min} \sim 0.5$ K and E_{max}. E_{max} will be much higher than the temperature of interest. We do not mean, of course, that no tunneling states appear below the energy difference E_{min}, but that the density of tunneling states with an energy difference below E_{min} is very low. The formula representing the heat conductance, R_K^{-1}, has the thermal integrand $\exp(x)\, x^6/[\exp(x)-1]^2$, which has a maximum for a value of x a little less than 6. Thus, one would expect that a resonance will have its strongest effect at $x=E/k_BT \sim 6$ and hence at lower temperature than $k_BT \sim E_{min}/6 \sim 0.1$ K the tunneling states will not contribute to the heat transfer. This is one of the major results of the tunneling mechanism.

The tunneling states are close to each other and interact strongly. The states are unstable and a higher order perturbation calculation (than the second order) becomes important. An explicit calculation of P_k from this mechanism shows that the efficiency of heat transfer becomes strong in a temperature range above 0.1 K. Above about 1 K the calculated temperature dependence of R_K is proportional to $T^{3.5}$ (in good agreement with experiments). Although the theory is applicable to the other quantum media such as solid H_2 or D_2, it is important to take account of significant differences of the tunneling states between He atom and H_2 molecule. The H_2 molecules, closely bound to the boundary, by bonding states of a highly anisotropic nature, will be sensitive to the surface condition of the solid. The tunneling states of H_2 molecules have a wide range of energy distribution compared with the case of the helium system.

In summary, as a result of recent developments of experimental techniques the problem seems to be entering a new stage. My theoretical results suggest that an important mechanism has been left out of earlier works and that heat transfer via tunneling of helium atoms close to the interface becomes strong for temperatures above about 0.1 K. I conclude that tunneling states of "quantum" atoms close to a boundary may play an important role in anomalous heat conduction.

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POLYMER RHEOLOGY AT NAGOYA UNIVERSITY

E. A. Kearsley

In polymer circles in the United States Professor Mitsuru Nagasawa is particularly well known since, over the years, he has probably spent a total of four years or more at various institutions there. Furthermore, he has co-authored (with Stuart Price) a definitive book on poly-electrolytes which has earned him world-wide reputation. Nevertheless, I did not know who he was when I recently heard him deliver an invited paper in Kyoto at the annual meeting of the Polymer Society of Japan. Since the talk was on the rheology of polymer solutions rather than on polyelectrolytes, I might have excused myself on the grounds that I was really meeting him "out of context," but that excuse seemed a bit thin when I subsequently visited him at Nagoya University and discovered that we had each published in the same recent issue of *Transactions of the Society of Rheology* and that in those articles we had each referred to works of the other. Fortunately, there is at least one more Nagasawa doing polymer research in Japan so that there is another excuse to fall back on.

Professor Mitsuru Nagasawa, in the Department of Synthetic Chemistry, Faculty of Engineering, Nagoya University, seems to be deeply involved in all aspects of the physical chemistry of polymers. Without a doubt, however, his pet subject is still polyelectrolytes and, in particular, the problem of relating the mechanical and other physical properties of the polyelectrolytes to the molecular electrical forces. Polyelectrolytes are polymers containing significant amounts of dissociative radicals in their structure and are common and important materials. They occur in biology (proteins and nucleic acid for instance), in ion-exchange resin, in membranes exhibiting selective transmission of ions and in commercial flocculants, adhesives and certain fibers. Nagasawa tells me that in his opinion only a rough and insufficient analysis of the electrical effects on molecular chain dynamics of polyelectrolytes has been achieved to date and he would like to complete a more satisfying, proper and detailed analysis. This year the Japan Academy awarded him a prize for his past work on polyelectrolytes.

The book entitled *Buttai-no-Henkeigaku* (which might be rendered *The Theory of Deformation of Matter*) published by the late Misazu Yamamoto has had a tremendous influence on recent rheological developments in Japan. In the early 1960's, Professor Yamamoto of Tokyo Metropolitan University was probably the only Japanese researcher whose work could be classified as pure rheology. In those days Yamamoto, who was a theorist, must have felt pretty isolated. At one point he approached his friend Nagasawa to undertake some experimental studies he needed. Thus, in the late '60's a model R-17 Weissenberg Rheogoniometer was aquired and, with this equipment, Nagasawa began by measuring normal stress and shear stress of polystyrene solutions in polychlorinated biphenyl (PCB). He first reassured himself on the plausibility of his measurement technique by verifying the relations between the normal stress and shear stress expected of a second-order fluid. (A second-order fluid is a particularly simple generalization of a linear visco-elastic material which can be expected to apply quite generally, in the limit of small amplitude for materials of a wide rheological class.) In the process of doing this, he and his colleagues unexpectedly found it necessary to take into account the compliance of the measuring apparatus; procedures for doing this were worked out for subsequent use. Thus prepared, Nagasawa began a study of the dependence on molecular weight and on molecular weight distribution of the mechanical properties of moderately concentrated polymer solutions. It is commonly supposed that in such solutions undergoing shear the long molecular chains "entangle" and that entropy elasticity, as in a rubber, results from the stretching out by the flow of the coiled chains. Nagasawa likes to think in terms of entanglement "rupture" to explain the non-linear phenomena of polymer solutions and, in this, he often cites the work of Tanner and of Graessley who picture these processes similarly. As did Yamamoto, he tends to try so-called "rate theories" for which the stress depends on the history of the invariants of the rate of strain tensor (rather than the history of

the invariants of the strain). This sort of question can be conveniently related to the growth and decay of stress upon starting up and stopping a simple shear flow and Nagasawa has been looking at such experiments. The questions raised are still definitely open ones. Recently, several laboratories have shown clearly that a simple rate theory cannot possibly explain such data and in the article mentioned above, I show that strain theories are consistent with at least one set of such experiments. On the other hand, I understand that Graessley at Northwestern is about to publish a set of data which is inconsistent with either the simple rate theories or the simple deformation theories. Nagasawa agrees with the consensus among rheologists that a simple rate-theory just won't do. He proposes to rectify the matter by explaining transient phenomena in terms of after-effect functions (associated with the initial and final structures in the material) blended by means of a transition function which is triggered by a critical value of strain. In short, he is attempting to preserve the idea of a rate-theory but at some cost in greater complexity. Complicating all these considerations are questions of the reliability of measuring techniques. The model R-17 Weissenberg Rheogoniometer is an unusual model with an electromagnetic expander used to compensate for any "springing" of the instrument due to normal forces exerted by the shearing sample. Nagasawa is satisfied that he is getting reliable data at least for times greater than one second. I am struck by the fact that it is only for times less than one second that I have found my own normal force measurements inconsistent with the strain theories I favor. I am tempted to say glibly that we are in agreement on this unreliability of the normal stress data for times less than one second but, to do so, would really be superficial since the reliable time range should depend on sample properties, geometry and other variables. To put it as your broker might, I am nonethless gratified that we are not in disagreement on this point.

Well characterized samples of polymers are the life-blood (or perhaps mother's milk) of research on the molecular mechanisms of physical properties. Professor Nagasawa has specialized in synthesizing his own samples particularly very narrow molecular weight fractions. For this purpose, he uses a technique known as anionic polymerization to produce what are sometimes called monodisperse polymers. Such polymers are nowadays even commercially available but Nagasawa feels these commercial "monodisperse" polymers are often neither sharp enough nor in a high enough molecular weight distribution effects on the viscoelastic properties of linear polymers (and incidentally, also for use as standard samples for gel permeation chromotography, GPC). For technical reasons he chose to synthesize poly (α-methyl styrene) rather than polystyrene and by this choice, he was able, for instance, to produce two samples with weight average molecular weights of 1.4×10^6 and 1.2×10^7 respectively and with ratios of weight average to number average molecular weight of about 1.02. That is indeed a narrow fraction since it implies a standard deviation of the number average molecular weight of only about 0.15, surely sharp enough to be called monodisperse.

Solutions of these monodisperse samples were used in an interesting study of the viscoelastic properties. Measurements of the response to sinusoidal shearing were made on the rheogoniometer mentioned earlier. The results, put in terms of relaxation distribution function, clearly broke up into two "humps." One of these humps shifts to higher relaxation times with increasing molecular weight of the sample and the other is relatively insensitive to molecular weight change. Nagasawa associates one peak primarily with motions of segments of the polymer chains and the other with molecular motions possibly mixed with segmental motions. The two mechanisms could not be separated in the past because these unique samples, simultaneously monodisperse and of extremely high molecular weight, were not then available. The idea may prove valuable in designing polymers with desired mechanical properties through controlled chemical structure.

The effects of branching on polymer properties is of great practical interest because most commercial polymers are more or less branched. Nagasawa has also synthesized comb-shaped polystyrenes with various numbers or branches and various molecular weights of branch and parent polymer. The samples were fractionated and characterized carefully. Currently, star-shaped molecules are being synthesized in poly (α-methyl styrene). In all these synthesized branched polymers the ratio of branch length to parent molecule length was large compared to the usually encountered branched polymers. This is an important feature for emphasizing the effects of branching. Nagasawa is systematically studying the effects of polymer concentration, molecular weight and branching number on the mechanical properties of these solutions. Of course, the synthesis of polyelectrolytes has not been ignored either and he has made narrow distributions of poly (acrylic acid), also by anionic polymerization. The combination of stiff molecular "backbone" and high molecular weight occurring here and

playing an important role in these researches posed a particularly difficult chemical problem. I understand that this single synthesis program actually extended over some five years.

Now, I have some good news and some bad news for you. Polymeric samples such as these are invaluable and coveted world wide. The good news is that Professor Nagasawa is extremely generous and has usually synthesized ample batches and then shared them with scientists around the world. (He mentions specifically the United States, Britain, Germany, USSR.) The bad news is that the fire department in Nayoga has made strict regulations on the amount of volatile solvents allowed in the laboratory and, I was told, even 50 gram samples are now more then can be managed in a synthesis. Regulations also forbid any use of PCB's and Nagasawa tells me with a wan smile that having recently served a term as faculty overseer for these regulations he is doubly bound not to stretch them. The regulations strike me as absurd but, who wants to argue with the Nagoya Fire Department?

As has been implied, polymer characterization is also a long suit at this laboratory, complementing the synthesis program. Nagasawa, a member of the committee on polymer characterization of the International Standards Organization (ISO), has many years of experience and a well equipped laboratory for this job. I was shown a Beckman Spinco Model H Ultracentrifuge, some ten years old, which I was told is a "vintage" model. To go with it were some sample holding cells designed and produced in the laboratory. The interesting thing is that the cells were made without surfaces to the level of high quality optical flats, the cell was pressed together and held in place by contact forces. Upon hearing that the maker of this marvel was no longer in Japan you can be sure that I very carefully set the cell down in a safe place. The use of cemented joints produces residual disturbing strains in ordinary optical cells, but Rayleigh fringes were clearly visible in the sedimentation of both solvent and solution made with this cell because of its special construction. Nagasawa told me that an index of refraction cell similarly made had improved the accuracy of such measurements by a factor of 10 over that of conventional cells. Other equipment for characterizing polymers included an X-ray diffraction apparatus, a Zimm viscometer (a type of rotational viscometer with a magnetically suspended bob to avoid effects of surface tension) and an osmometer. Professor Nagasawa suggested that a GPC apparatus (which is delicate and must be kept up) is really too expensive for a university laboratory where it is ordinarily seldom used in comparison to the heavy routine usage in an industrial laboratory. He is very fortunate in having the help of a former student, Dr. Tadaya Kato, who now works for Toyo Soda and who is an expert in GPC determinations of molecular weight. With obvious pride, Nagasawa told me the story of how Kato as a student had challenged his statement that only sedimentation studies could separate "comb" molecules and had then proceeded to perfect his GPC techniques until he could clearly resolve them.

Another really beautiful piece of equipment was a streaming birefringence apparatus with precisely designed and exquisitely machined parts all set in a large concrete block to hold alignments. A special plastic cover included the operator and protected the apparatus from air currents. Even so, it is so sensitive to vibrations that it is best operated at night when activities are at a minimum. Nagasawa told me that many of the most critical parts had been machined by small engineering companies run by Nagoya University graduates. They did a particularly careful job at a very low price. His only complaint was that it is difficult to find a graduate student willing to take on the arduous task of utilizing this remarkable equipment; Nagasawa estimates that a five year program of research will be needed to capitalize on it. The complaint is one I have heard from academic friends in the United States also and there is apparently a world-wide shortage of good graduate students in science, particularly if the field is not a trendy one. In this case, the plan is to study streaming birefringence in dilute solutions of polymers, certainly not a subject often met in the newspaper headlines though who can deny that it has its own importance. Of course there is much work in polymers at the University of Nagoya which is less oriented toward rheology. I have really not touched on the work in polyelectrolytes by Nagasawa's group, for instance. In addition, Professors Sumitomo and Yamashita do polymerization studies and Professor Miyahara works with dilute solutions. I had no time to investigate that work and perhaps it is best left to a more chemically sophisticated reviewer anyway.

CONSTITUTIVE EQUATIONS AT THE NINTH INTERNATIONAL CONFERENCE ON SOIL MECHANICS AND FOUNDATION ENGINEERING

E. A. Kearsley

This year during the week of July 10 Tokyo seemed to be invaded by a variety of world citizens wearing cryptogrammic badges which read "IX ICSMFE." The Ninth International Conference on Soil Mechanics and Foundation Engineering was in progress at the Imperial Hotel and the participants were touring subway construction sites, probing Tokyo Bay's man-made islands, poking around Tama New Town (a satellite town of Tokyo), inspecting the new tunnels being constructed under Tokyo Bay and examining the special piles and other innovations of Musashino Railway yard. Modern soil mechanics is said to be only about 50 years old even though by the 18th Century Coulomb had suggested a yield condition to be used in designing earthen structures. The first international conference took place at Harvard University in 1936 just over 40 years ago, but this conference in Tokyo is the first such to be held in Asia. Actually, Japan is a particularly appropriate place to hold this meeting since it is a center of considerable research in the field. Building is at a high level of activity in Japan and, because it is densely populated and mountainous with limited inhabitable land, high buildings are often built on sites posing serious soil mechanics problems. When you add to this the facts that landslides and earthquakes are not uncommon occurrences and that filled-land and ocean-bottom constructions are frequent, it is easy to see the basis for the great interest in soil mechanics. Beyond that, now that large scale civil engineering is a highly competitive, world-wide business of considerable magnitude, Japanese construction companies are very active overseas as well particularly in Southeast Asia and in the Middle East.

Come to think of it, the international aspects of this conference can hardly be overemphasized. Believe it or not, the published list of preregistered participants was broken down by continents, since to classify by country would have required over fifty categories. The results were as follows–Africa 12, Asia (excluding Japan) 62, Australia 18, Europe 350, North America 131, South America 42, and Japan 403. This tally accounts for over 1300 delegates but I was told that including late registrants the total was expected to exceed 2000. By the way, the North America figure includes Canadians, Mexicans and Central Americans so that the United States delegates at this conference were very far from dominant. The meetings themselves were run largely in English, but at each seat was a little black box with earphone with which one could switch to simultaneous translations of the proceedings as needed (French, Japanese or English). A typical day of the meeting began with a special lecture, e.g., "Geotechnical Aspects of the Construction of Shinkansen" delivered by Dr. M. Fujii, a former president of Japan National Railways. (The Shinkansen is the railroad line of the famous "bullet-trains," frequent super-expresses which achieve speeds of 210 km/h. between Tokyo and Hakata.) The rest of the morning was then devoted to a Main Session on some topic, often didactic and usually fairly technological. Afternoons offered a choice of three Specialty Sessions usually with a range from quite general topics, e.g., "Relationship between Design and Construction in Soil Engineering" and "Computer Analysis in Soil Mechanics; Present and Future," to quite specific topics, e.g., "Ground Anchors" and "Deformation of Earth/Rockfill Dams." In addition to these technical sessions, tours were available to Tokyo sites of interest from a soil mechanics point of view (whence the polyglot tourists mentioned before).

In such a large meeting, with some 240 papers offered to 2000 participants, general discussion must be somewhat controlled. In fact, much use was made of preprints and at the actual sessions there was only time for a review by a General Reporter followed by a discussion by the Session Panel. Questions and discussion from the floor were submitted in writing and of them only a limited selection could be considered by the panel.

As a spot check on the conference I chose to monitor the "Specialty Session on Constitutive Equations of Soils" on the principle that my background in rheology would help me to follow the proceedings. That may well have been a mistake. My rheological experience has been principally with polymer solutions and rubbery materials. The terminology of this session was largely completely foreign to me (the little black box was no help here) and the system of written questions from the floor did not encourage the like of, "What is a Loess-Triangular-Chart?" or "What is Perzyna's theory?" Thus, you may detect a slightly surrealist flavor in the resulting impressions.

I began by purchasing (for ¥2,300) a volume of the preprints for this Specialty Session. A quick scan in anticipation of the about-to-begin session left me without much feel for the sort of rheological behavior that might be typical of a soil and it was only as the session progressed that I began to see why that was. Typical soils are generally very complex structures. They are an aggregate of irregular particles held in place by normal contact forces, Coulomb friction and perhaps (there is controversy on this point) by cohesive or chemical forces. The voids between these particles may or may not be partially or totally filled with water. The well known observation (attributed, I think, to Reynolds) that footprints in the surf-wetted sand of a beach are rimmed by mounds of drained sand is often cited as proof that the shearing of the sand induces an increase in volume (dilatancy) greater than the decrease caused by compressing. This is not surprising when you mentally picture the deformation of tightly packed assemblies of irregular particles nor is the fact that, contrarywise, loose sand exhibits a decrease in volume on being sheared. But the consequence is that the concept of incompressibility is not of much value for soil mechanics and quantities such as degree of consolidation and void ratio cannot be ignored. Even the simplifying idea of isotropy is of limited use since many soils show strong anistropies depending on how they were laid down. With so many variables to contend with, the range of possibilities is tremendous.

Theories of soil tend to be classifiable as structural or phenomenological. The structural theories attempt to work from the micromechanics of the interacting particles through statistical averaging to the mechanical field quantities. Phenomenological theories, on the other hand, work directly with plausible restrictions or assumed relations on the field quantities (in the best work these restrictions are intuitively based on a feeling for the microstructure).

On the other hand, the soils themselves (or at least those discussed at this conference) tend to fall into two classes also. Dry sand is perhaps the clearest example of a class which might be called cohesionless soils. The microstructure for these materials is usually pretty clear and focuses on the question of the statistics of the contact angles (hence the sliding friction) between particles. The process of getting from that simple picture to the dynamics of distributions of random variables and thence to specific constitutive equations is not so clear. A wide range of papers dealt with these problems of developing a "statistical mechanics" of cohesionless soils. S. Murayama, Professor Emeritus of Kyoto University, had a series of papers outlining the results of a research program of many years standing. His colleagues and former students were well represented also. A contrasting paper was that of T. Dietrich of Bundesanstalt für Materialprüfung who presented a fresh doctoral thesis on "Psammic Materials" done in the axiomatic style of the "rational mechanics" school. C. Thornton of the University of Aston (U.K.) had worked out the mechanics of a simplified "two-dimensional soil," an array of packed rods. It is known that to test three-dimensional soil theories triaxial stress situations must be measured and Thornton's results offer a dodge for trying out simplified test cases of the various theories in two dimensions.

Phenomenological theories of cohesionless soil tend to be elaborations of plasticity theory. Although the mathematical theory of plasticity in modern times has been primarily developed for representing the behavior of metals, the tradition in soil mechanics goes back to the 1773 paper of Coulomb cited earlier. The term "modern soil mechanics" corresponds pretty well to a recent renewal of development in this direction. Various papers in the preprints were on new proposals for yield conditions and on modifications to associated flow rules or other consequences of anisotropy.

The second class of soils considered is characterized by wet clay which was the subject of a great number of papers. (Occasional papers on rock, loess and tuff also occurred.) The most important complication added by

this class is the appearance of significant time effects: stress relaxation, creep rupture, rate dependency, secondary consolidation and so forth. Presumably, much of the work on cohesionless soil may be adopted here to describe the "skeleton" of particles forming the clay, but the effects of the void filling water and of cohesion must somehow be taken into account. There was a good deal of controversy at this meeting over just what, if any, cohesional forces did act. "Hydrogen bonding" was a term which was used and produced strong objections. Professor T. Matsui of Osaka University was adamant that solid-to-solid adhesive contact is important in clay (except when so diluted with water as to form a suspension). To make his point he displayed electron microscope pictures of kaolinite particles (from clay that had been sheared while under a compression of 1.5 kg/cm^2) which showed markings reminiscent of a glacial boulder. Unsheared kaolinite from the same source was said to show no such markings.

There is another school of thought that Eyring's ideas of rate-processes ought to apply to shearing clays. Professor R. Pusch of the University of Luleå (Sweden) was firmly opposed to the idea. He pointed out that the heterogeneities of deforming clay invalidated the assumptions used in applying the idea. Indeed, he seemed to be borne out by a moving-picture of a large two dimensional model of a clay consisting of a thick sheet of rubber plastic with odd-shaped, Swiss-cheese like holes. Under compression some sections of the material completely collapsed while other sections showed only slight deformations. The point of this demonstration was that limited parts of a highly inhomogeneous material bear an inordinate amount of the deformation and that the calculations of the energy of breaking contacts should take this into account. Pusch concludes his argument with the statement, "Since neither the stress distribution nor the microscopic deformation pattern of aggregated clay are in accordance with the assumptions made in practical application of rate process theory, no reliable conclusions can be drawn as concerns the nature of the clay particle bonds. The least reasonable application of this theory even indicates that hydrogen *bonding through thin* continuous interparticle water films is more probable than bonding through primary valence bonds in mineral/mineral clay particle contacts."

More classical approaches to constitutive equations for soft clays are often based on a model known in the trade as Cam Clay—a development of Cambridge University which emphasizes energy considerations. This model has the features of plasticity theory, e.g., yield conditions and associated flow rule. Many papers among the preprints were elaborations or modifications of this model. A. N. Schofield, of the Cambridge group, gave a wrap-up summary of the session which struck me as a glowing encomium of Cam Clay. In effect, he felt that there had been worthwhile modifications but no definitive changes offered, that the introduction of anisotropy raised the question of whether fully softened critical states were also anisotropic but that, by and large, where the Cam Clay model deviated from reality, it was a beneficial deviation either by reason of the simplicity gained thereby or because it assured an extra margin of safety in foundation design. I can hardly believe that all of the 300 or so attendees at this Specialty Session were as satisfied with the current state of things.

A KUROSHIO TRACKING EXPERIMENT

A. C. Vastano

During February 1977, a study of the Kuroshio Current and its mesoscale variability began as a joint experiment by oceanographers from Texas A & M University, Tokyo University and the Japan Hydrographic Department. This effort, involving satellite tracked drifters, is part of the research activities of two ONR-sponsored, TAMU investigators, Dr. A. D. Kirwan and the writer.

Four drifters were launched on Julian days 50 and 51 from the vessel R/V Takuyo of the Japanese Hydrographic Office. These free instruments were drogued with a parachute at 100m and they report position, temperature, drogue and battery status twice daily by the polar orbiting Nimbus 6 Satellite. The drifters were placed in sequence (identification numbers 106, 130, 307, 341) southeast of Toi Misaki, Kyushu Island, with 106 and 130 launched on either side of the high speed core of the Kuroshio as determined by GEK measurements. Drifters 307 and 341 were set to the seaward side of the core. The trajectories for the first 30 days are shown in Figure 1.

The general flow pattern revealed by the drifters south of Honshu is an expression of the meander present there. This feature is one of two modes of motion recognized for the Kuroshio in the Shikoku basin. The trajectories indicate that the meander leaves the continental slope near 135°E longitude and flows southeastward over the Kinan Seamounts before turning northward, parallel to the Izu-Ogasawara ridge at 140°E (see Figure 2). The movements of the drifters correlated well while they were in the basin south of Japan although their travel times around the meander vary considerably. The time sequence for crossing the Izu-Ogasawara Ridge spanned 20 days, from Julian day 64 (drifter 307) to day 84 (drifter 341). The trajectories have shown possible routes for the Kuroshio as it leaves this region and proceeds eastward. Two small eddies associated with topographic interactions of the current were traced at 135°E and 139°E.

The trajectories described by the drifters in the western North Pacific Ocean show a remarkable set of dynamic features as well as spatial and temporal correlations (see Figure 3). The paths were widely separated at times, only to converge quite closely later. Drifters 307 and 341 give such an instance between days 80 and 100. Movement of this nature and, for example, the separation of drifters 130 and 106 on day 100 are of great interest to biological as well as physical oceanographers. The drifters were initially placed in the Kuroshio close together. The evolution of their trajectories in the North Pacific effectively traces water mass and ecosystem boundaries and the mesoscale perturbations of these boundaries. The excursion of drifter 106 northward to 39°N at 148°E is an instance of this latter phenomenon. The circular motion in this vicinity indicates an anticyclonic eddy in the frontal zone and the presence of relatively warmer Kuroshio water north of the Kuroshio front.

In July, two TAMU oceanographers, Dr. John Wormuth and I came to Japan to initiate joint physical and biological studies of frontal zones and associated mesoscale features with Japanese colleagues. These investigators are presently involved in the Gulf Stream Cyclonic Ring Experiment supported by the Office of Naval Research and the National Science Foundation. Complementary research interests have been identified and plans made to begin joint studies of the unique mesoscale problems associated with the Kuroshio. In particular, an investigation of the biological implications of the 1977 drifter tracks will be carried out with scientists at the Ocean Research Institute of Tokyo University.

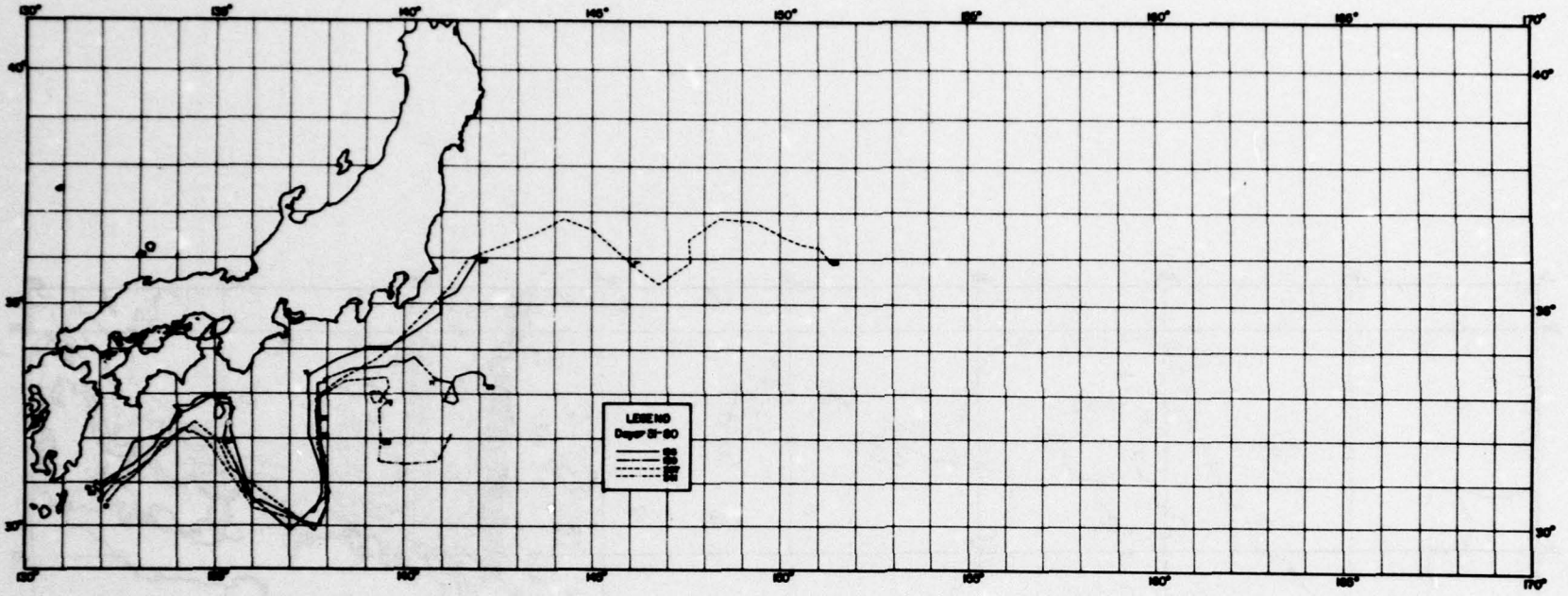

Figure 1

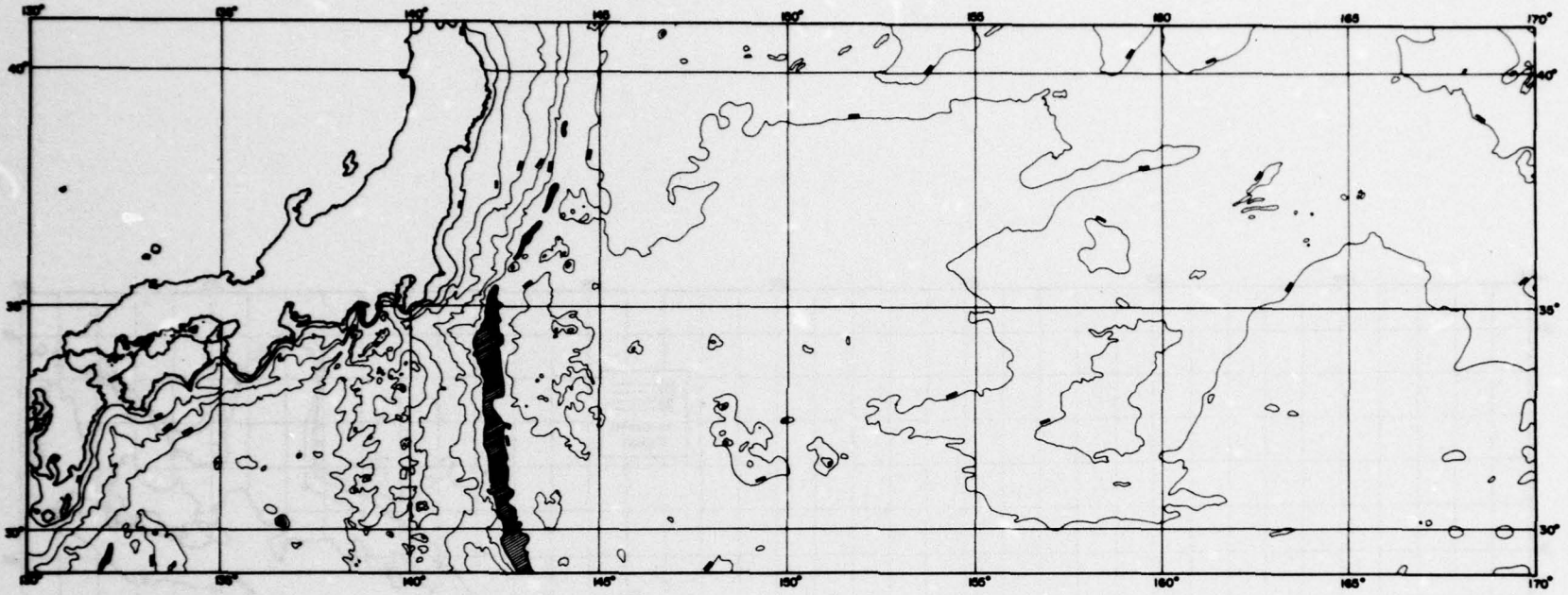

Figure 2

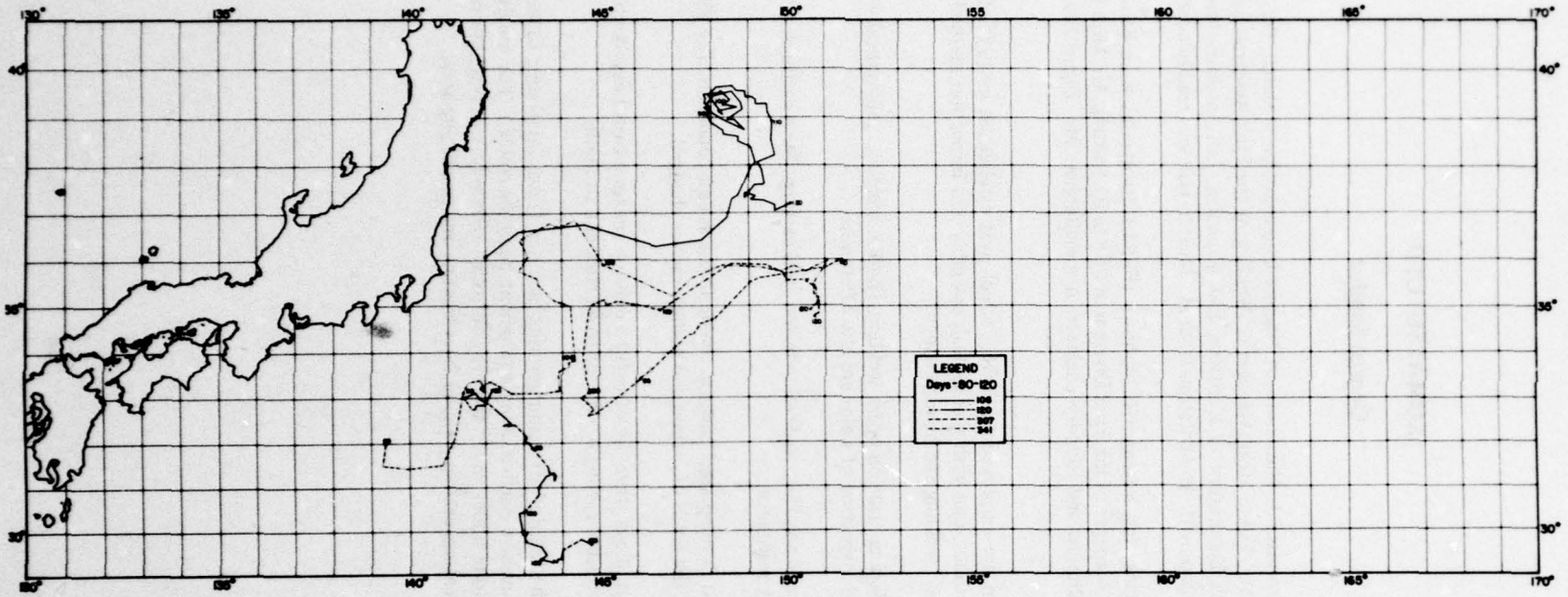

Figure 3

KOMATSU, LTD.

George Sandoz

While speaking with Professor I. Masumoto of Nagoya University on 1 March, the writer had the good fortune to be introduced to Mr. Yukio Mori, Manager of Welding of the First Research Laboratory of the Production Engineering Research Laboratory of Komatsu, Ltd. Komatsu, Ltd., manufactures a variety of construction and earth-moving equipment. An invitation from Mr. Mori to visit was readily accepted.

At the Production Engineering Research Laboratory (PERL) discussions were held with Mr. Mori and with Mr. Masao Kikuchi, the Manager of the First Division of PERL. By training, Mr. Mori is a welding engineer while Mr. Kikuchi is a metallurgist and foundry engineer. A metallurgist, Mr. Taguchi is General Manager of PERL.

Approximately 80 men are employed by PERL, which was established in 1975. One division is concerned with management methods, one with mechanical, assembly and inspection methods and the last (First Division) with research foundry, welding and heat treatment.

The weld shop is developing electron beam welding, friction welding, automatically controlled welding, and arc welding. The NDE and inspection of welds are also of interest.

In the casting area there is an effort to develop boron steel castings. Such castings, after water quenching, are claimed to have high shock resistance.

There are also efforts to develop steel castings usable in the as-cast condition. The yield strength is raised by additions of vanadium and the levels of carbon and manganese are changed.

In the case of aluminum alloys there are efforts to develop pressure-cast, heavy-section, hydraulic pump gear cases of aluminum. The pressure casting is a means to increase the strength.

The visit concluded with a tour of the manufacturing facilities. It was interesting to see the applications of welding and to observe the massive earth-moving equipment being assembled. The building of these massive machines, some of which operate under water and are controlled remotely, involves almost every metallurgical specialty in the fabrication, welding, casting, forging, heat treating and machining areas.

NIPPON STEEL NAGOYA WORKS

George Sandoz

The Nippon Steel Works Laboratory at Nagoya serves the thick-plate production activities of the company. Thick plates have been in increasing demand as industrial plants and equipments have tended to become larger and subject to more severe requirements in recent years. Thermal and nuclear power plants, for example, require large boiler drums and pressure vessels and fuel oil desulfurization reactors require high temperatures and pressures.

The Nagoya Works has a capacity of seven million tons annually. Plates up to eleven inches thick weighing up to 50 metric tons can be fabricated (reportedly, only one U.S. company can produce plates this thick). Other than the problems associated with the mechanics of handling such massive plates, there are the expected problems with porosity, microcracks, purity and uniformity of composition which are common to the production of large ingots which cannot be hot worked or reduced very much.

Nippon Steel uses 15, 50 and 100 ton basic electric arc furnaces (with electromagnetic induction agitators) to produce forged slabs and a basic oxygen furnace to produce rolled slabs (the slabs in each case are subsequently rolled into plate). The basic electric furnace produces ingots which are very large and these ingots are slabbed by hot-forging with an 8000-ton forging press. This is useful in removing or healing blowholes and microcavities in the ingots through plastic deformation. The conventional electric furnace, however, requires the use of scrap, which creates some problems with purity which are avoided with the basic oxygen furnace which does not require scrap. The latter furnace is therefore attractive for smaller plates with which sufficient reduction can be obtained in the slabbing rolling mill.

All slabs are heat treated and surface conditioned prior to plate-mill rolling. Following this the plates are again heat treated prior to inspection, straightening and final mechanical properties tests. Hydrogen is always a problem with large ingots and plates, because the diffusion path to the surface is long and hairline cracks may therefore occur during cooling. Nippon Steel removes hydrogen through vacuum degassing of all melts and through dehydrogenation during heat treatment for the slabbing and plate-making processes.

A wide variety of plate steels is produced to satisfy varying service requirements. Thus a series of weldable high-strength steels (WEL-TEN class) is produced with tensile strength ranging between 60 and 100 Kg/mm^2. The N-Tuf steels are intended for low temperature service (-40° to -196°C). A number of low-alloy steels for medium-high and high-temperature service in high-temperature, high-pressure vessels are made. Atmospheric corrosion resistant steels of the CORR-TEN type and NAW type are also produced. The steel S-TEN is resistant to sulphuric acid. Abrasion resistant steels of the WEL-TEN and NAW class are made with increased hardness by use of lower tempering temperatures.

The research work conducted by the laboratory involves the problems of purity, segregation, porosity and structure which are inherent to thick plate manufacture. The problems of fabrication and welding relate to these problems, and are also of interest. It is desired always to maximize toughness, weldability, and fabricability and to tailor properties at minimum cost to meet specific service requirements. Some specific research areas and problems which were discussed on this visit follow:

(1) Welding of High-strength (80 Kg/mm^2, 100 ksi) Steel for Pressure Vessels–Pressure vessels are field welded under unfavorable environmental conditions. One hundred percent joint efficiency is required and the welding has to be done under great restraint because such heavy plate is used.

Semi-automatic and automatic welding procedures are gradually being introduced for the 80 Kg/mm^2 steel (WEL-TEN 80) but SMAW remains the dominant practice, especially for spherical tanks. Unfortunately SMAW welding efficiency is influenced greatly by the operator's skill. Other problems which become intensified in the welding of high-strength steel are: 1) the steel HAZ is embrittled by high temperatures and the plate cannot be readily press strengthened or formed; 2) the high strength steels are more susceptible to the harmful effects of hydrogen, and elaborate steps for preheating and post heating and a large number of passes are required; and 3) high strength steels are notch sensitive so that misfits and other sources of notch effects must be controlled.

Nippon Steel has prepared detailed manuals for the welding of high strength steels which describe the proper selection and drying of weld materials, give welding procedures and welding conditions for butt and filet welding and specify heat input and bead length restrictions.

(2) Plates for Heavy Section Nuclear Reactor Pressure Vessels–In a recent publication (Nippon Steel Technical Report Overseas No. 7, November, 1975) steelmaking procedures to minimize impurities and residual elements which cause irradiation embrittlement and the means to employ hot working and deflaking heat treatments are described. The optimum procedures are claimed to provide quality assurance and pressure vessel integrity, on the basis of COD, DT, fatigue and weldability tests. Steels of this type, low in the amounts of the harmful elements Cu and P, are currently under test at the Naval Research Laboratory (Code 6390).

A paper on the improvement of fracture toughness in reactor pressure vessel steel plates was scheduled for presentation at the Third International Conference on Pressure Vessel Technology in Tokyo, 18-22 April, 1977. The authors, H. Kunitake, H. Nakao, T. Kikutake, A. Saito, T. Isiguro and T. Takeda, report that the BOP process is effective in minimizing the concentration of harmful elements. With respect to SA 533 B steel, residual sulfur is harmful to upper shelf Charpy-V test energy. Transition temperatures are lowered by decreasing carbon levels and increasing the hardenability with manganese nickel and molybdenum additions. A small amount of chromium lowers transition temperature as does control over aluminum and nitrogen levels. Tests on a commercial scale production heat of SA 533 B steel with optimum composition bear out the experimental predictions.

(3) Environmental–There are problems with stress corrosion cracking of line pipe steels and oil drill casing steels which are being studied. The problem is embrittlement or cracking by H_2S. Tests are being conducted in 5 percent NaCl-water at temperatures between 10°C and 80°C and with pH varied by CH_2COOH additions. The level of H_2S is varied by saturating the solution with various H_2S-N_2 gas mixtures.

The company has evidently been able to increase greatly the resistance to H_2S by the judicious control of composition and by purposeful small additions of certain elements. These were discussed but the writer promised the details would not be disclosed.

In general the Nagoya Works Laboratory is excellent and the work there is in keeping with the high standards observed previously in the Fundamental Research Laboratories and the Product Research and Development Laboratories of Nippon Steel.

TOYOTA CENTRAL RESEARCH AND DEVELOPMENT LABORATORIES

George Sandoz

Toyota Central Research and Development Laboratories, Inc., was established in 1960 to provide research support for the Toyota Group companies. The current Director is Dr. Noboru Komatsu, who described the Toyota Group companies and their major interests and products as follows:

(1) Toyota Tsusho Kaisha Ltd.–Exporters, importers, general merchants.
(2) Toyota Automatic Loom Works, Ltd.–Spinning and weaving machinery, fork lift trucks, light trucks, automotive parts.
(3) Toyota Motor Co., Ltd.–Automobiles
(4) Toyota Spinning and Weaving Co., Ltd.–Cotton, woolen, synthetic yarns and fabrics.
(5) Toyota Motor Sales, Inc.–Sale of automobiles and parts.
(6) Toyota Machine Works, Ltd.–Grinding machines, milling machines, semiconductor strain gages, solid state devices.
(7) Aichi Steel Works, Ltd.–Spring steel, bearing steel, structural steel, stainless steel, tool steel.
(8) Nippon Denso Co., Ltd.–Electrical auto parts and accessories.
(9) Aisin Seiki Co., Ltd.–Auto parts, drive and brake compounds, die castings.
(10) Toyota Auto Body Co., Ltd.–Car and truck bodies.

The main activities of the Laboratories, many of which seem to be of interest to the Navy, are listed below:

(a) Materials processing, treatment, evaluation and structural analysis
(b) Applied mechanics and physics
(c) Control and servo engineering
(d) Combustion engines and heat transfer
(e) Battery and electrochemical phenomena
(f) Fatigue, fracture, wear and lubrication
(g) Chemical and instrumental analysis
(h) Radioisotope technique
(i) Electronics and optics
(j) Environmental and pollution control
(k) Sensors, including semiconductor strain gages
(l) Computer applications

Research programs and decisions are generated in the manner outlined in Chart 1. It is of interest that research proposals are a dual effort of administrators and research scientists and engineers. The needs for the research both inside and outside the Toyota Group are considered and there are extensive communications, contacts and surveys to assess what is new and what is ready for development within the capability of the Laboratory.

Following Dr. Komatsu's review of the managerial approach and research interests of the Toyota Laboratories, a one-hour talk on the materials research activities of ONR-NRL was given. Three selected presentations on research activities at Toyota followed, and these are described below:

(1) Dispersion Strengthened Alloys for Electrode Tips (Dr. Yamada)–Dr. Sen-ichi Yamada and N. Komatsu have developed copper alloys for service, among other applications, as electrode tips for spot welding. The alloys feature the double effects of solution and dispersion hardening in internally oxidized Cu-1Al alloys with additions of Ag, Pd, As and In. The high strength is retained up to 1050°C. The basic research leading to the development has been published in a series of papers in the Japan Institute of Metals Journal, beginning in 1972. The development is now regarded as ready for commercial sales following completion of the research last year.

(2) Semiconductor Strain Gages and Their Application (Dr. Igarashi)–Dr. I. Igarashi and T. Chiku describe a "Subminiature Three-Directional Accelerometer: An Application of Semi-conductor Strain Gages" in Instrument Society of America Transactions, Vol. 9, No. 2, p. 119, 1970. Basically three orthogonal cantilever beams are used, to which 1.7 mm x 0.2 mm x 0.3 mm p-type Si gages are attached. A half bridge circuit measures the voltage output of the gages. The entire accelerometer is about the width of a dime on each cube face. The accelerometers are useful in human factors engineering, as in measuring the acceleration of the head of a passenger upon impact in a simulated car accident.

A similar device is the semiconductor pressure transducer developed by Toyota Central R&D Laboratories. These transducers feature high sensitivity, small size (match-head dimensions), low hysteresis, response at high frequency and long life with good stability.

The sensing element of the transducer is a silicon chip, integrated with a set of diffused resistors which perform as sensitive strain gages through the piezo-resistive effect. The center of the chip is thinner than the edges and operates as a diaphragm. Pressure change on the diaphragm produces a small strain and a change in the resistors. This produces a change in the output voltage of the bridge circuit to which the resistors are connected.

The transducers have been applied in a number of ways. For example, they have been used to measure aerodynamic pressure distribution on the surfaces of helicopter and turbine blades, aircraft wings and bodies, and on large structures such as buildings and bridges (wind effects). They have also been used to measure pulse waves at finger tip, upper arm and neck in the human body. In this case a silicone oil contained in a vinyl film is used to transmit the hydrostatic pressure to the transducer. The transducers have also been applied in the measurement of physiological fluid pressures such as blood, spinal and ventricular. Another variation of the transducer measures intracranial pressures.

(3) The TD Process (Dr. Arai)–Dr. Arai reviewed the Toyota diffusion coating process (TD process) which was discovered in 1971 but has been under development since. The TD process won the Industrial Research Magazine IR-100 award in 1976. This award honors the top 100 new products, processes and materials of the year.

The TD process is in fact a series of related processes which serve to form a carbide, boride or alloy surface layer on a substrate metal, usually carbon steel. The layers formed are carbides of V, Nb, Cr, Mn, and other carbide formers, or alloys between the substrate and elements such as Mn, Al, Si, B, or Cr. The coating may be applied by dip, powder or paste methods, or by electrolysis in molten salts. The dipping method is apparently the most fully developed and the one which was discussed during the visit and which is described in company brochures.

The dip method involves a borax solvent at 800 to 1050°C, to which are added powdered carbides, ferroalloys or oxides of the coating metals. The part to be coated is dipped for from 1 to 10 hours, which gives the desired coating thickness of 5 to 15 microns.

The coatings are reputed to excell in wear and seizure resistance as well as to resist corrosion and oxidation. The coefficient of friction against steel is claimed to be 20 percent less than that of hardened steel. The

applications of the process are described in some detail in Toyota Central Research & Development Laboratories, Inc., publications dated February, April, June, September and October 1976. Mitsui and Co., Ltd., is the exclusive agent in the United States.

A series of scientific articles on various aspects of the TD process have been published by Arai and others in recent issues of JJIM (**39**, 247, 1975, **40**, 925, 1976, **41**, 68, 1977).

In general, the Research and Development Laboratories, Inc., of the Toyota Group are typical of similar wide-awake, aggressive and opportunistic industrial laboratories in the United States. It is perhaps too easy, however, to forget the contributions such laboratories make not only within the practical engineering-military world, but to basic scientific knowledge as well.

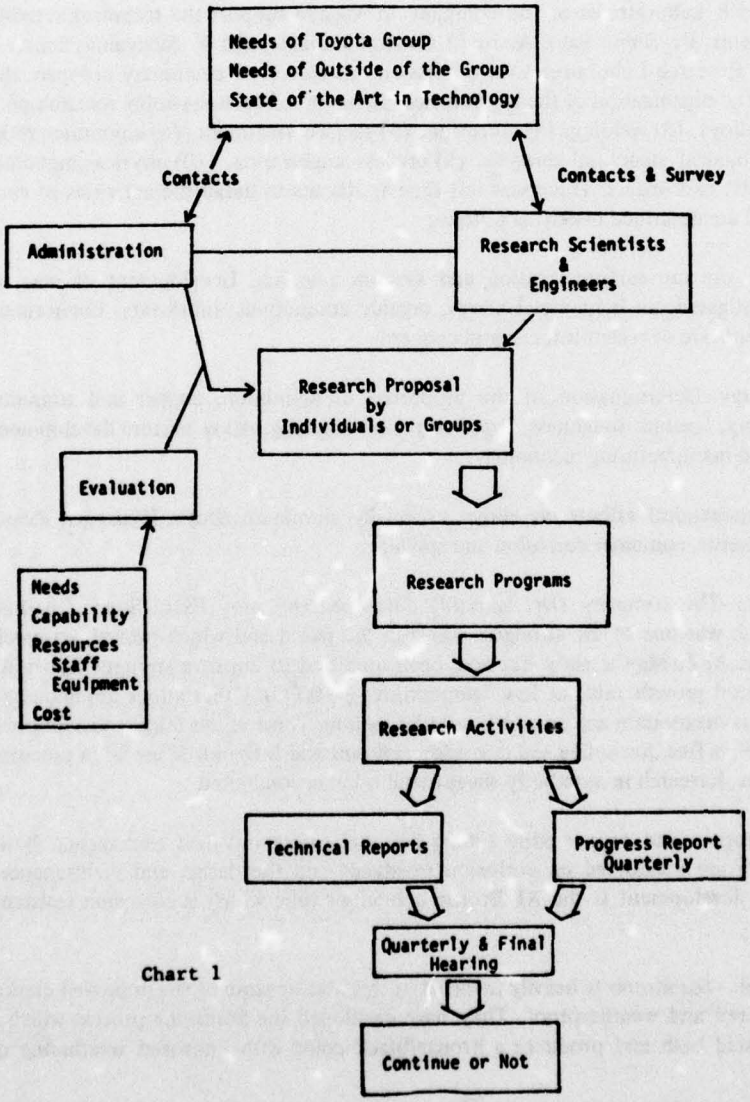

Chart 1

SUMITOMO LIGHT METAL INDUSTRIES, LTD.
NAGOYA PLANT

George Sandoz

Sumitomo Metal Industries dates back 300 years to when copper mining began in Japan. Copper rolling began in 1897, aluminum rolling in 1898 (the first in Japan). Sumitomo Light Metal Industries was established in 1959, when previous ties with steel companies were severed. In addition to copper and aluminum alloys, the company now produces titanium alloys in the form of tubes and plates for condensers and heat exchangers.

The Technical Research Laboratories of the company in Nagoya support the technical activities in the three light-metal alloy systems. Dr. Shino Sato, Assistant General Manager, and Y. Sugiyama, Senior Research Engineer, of the Technical Research Laboratories were hosts on this visit. As is customary in Japan, they began with a detailed account of the organization of the laboratories. There are 12 sections doing research on: (1) copper alloys, (2) aluminum alloys, (3) welding, (4) corrosion, (5) surface treatment, (6) aluminum refining, (7) chemical analysis, (8) mechanical structural analysis, (9) process engineering, (10) physical metallurgy, (11) metal working, and (12) heat exchangers. There was not time to discuss in detail the activities of each group. Those which were discussed are described briefly as follows:

(1) Analysis–Studies on auto-instrumentation and systems research. Development of new analytical procedures. Materials investigated are light metal alloys, organic compounds, lubricants. Environmental and pollution control requirements are of recent interest and concern.

(2) Physical Metallurgy–Determination of the properties of aluminum, copper and titanium alloys, mechanisms of age hardening, fracture toughness, stress corrosion cracking. Alloy texture development and effects, alloy development and manufacturing technology.

(3) Corrosion–Electrochemical effects on alloys, especially aluminum alloys. Hydrogen absorption in titanium corrosion environments, container corrosion and spoilage.

(4) Aluminum Alloys–The company (Dr. Igarashi) developed the alloy Extra Super Duralumin (AA 7075) before the war, which was one of the strongest alloys in the world and which proved extremely useful in Zero fighter planes. This Al-Zn-Mg-Cu alloy has now been modified to improve strength and resistance to fatigue crack growth (reduced growth rate) at low temperatures (-100°C). Other alloys developed are ZK60 and ZK61 which feature less magnesium and an addition of zirconium. These alloys display exceptional extrudability. Another alloy, GT09, is free machining and corrosion resistant and is therefore useful in precision manufacturing such as for cameras. Research in auto body sheet metal is being conducted.

(5) Copper Alloys–copper and copper alloy tubing for condensers and heat exchangers. Both fundamental and applied research are conducted on corrosion resistance and the design and maintenance of heat exchangers. An interesting development is the AP Bronze condenser tube which is corrosion resistant in polluted sea water.

(6) Surface Treatments–Sumitomo is heavily involved in this area because of the improved marketability of aluminum which is colored and weatherproof. They have developed the Sumitone process which involves anodization in a sulfonic acid bath and produces a bronze/black color with improved weathering qualities.

Color is also developed in the EDECA process which features the application of color in a soluble resin by means of an electrodeposition method.

(7) Welding—weldability studies of structural aluminum alloys, improvement of filler metals, inert gas arc welding, resistance and friction welding, adhesive bonding, brazing and soldering. Directed research on fluxless vacuum and inert gas brazing and ultrasonic soldering processes for aluminum heat exchangers.

Recent research has been directed at problems with condenser tubing in cooperation with some utilities in Japan. A substantial effort has also been made in the development of materials for desalinization plants. In the latter area, support has been received from the Ministry of Trade and Industry and the Ministry of Industry and Commerce. The Office of Science and Technology also sponsors work at the company.

Recent research reports (Sumitomo Light Metal Technical Reports, **17**, No. 3, No. 4, July, 1976) describe corrosion work on "Cathodic Protection and Blackening of Aluminum" and strengthening methods in "Thermo-mechanical Treatments of Al-Zn-Mg-Cu Base Alloys." An age-hardenable aluminum alloy which can be deep drawn (for cans, car bodies, etc.) is described as U.S. Patent 3,935,007.

Copper alloys are considered in an article on "Polarization Characteristics of Condenser Tubes by Impressed Cathodic Current." In another publication (Boshoku Gijutsu, **23**, 125-133 (1974)) Sato and Nagota wrote on "Stress Corrosion Cracking of Copper Alloys in Pure Steam and Water at High Temperatures." Alloys of Cu-Zn-Al were found to be susceptible to intergranular corrosion (in degassed steam at 150°C-300°C) with low Zn content and to exhibit poor stress-rupture strength with high Zn content. Cupronickel alloys 90/10 and 70/30 corroded intergranularly in steam and water at 300 to 350°C, and stress-corrosion cracking was produced in autoclaves with applied tensile stresses of 10 to 20 kg/mm^2. Monel metal was immune. The writers concluded that the stress corrosion cracking of copper alloys in high temperature water and steam is associated with the equilibrium grain boundary segregation of active metals.

No specific research on titanium alloys was discussed, but some interesting related service experiences were described. Titanium alloys are quite immune to corrosion in seawater over a range of temperature and in more concentrated brines at temperatures below 80°C. If the brine concentration and temperature are both high, there may be problems with pitting and crevice corrosion, particularly if the solution pH is low. This can be a problem with titanium condensers. On the steam side at the air removal section the non-condensable gases NH_3, O_2 and CO_2 are concentrated; this is highly corrosive to copper alloy tubes, but the titanium tubes are free of corrosion. In tests in power plant condensers over the past decade, thin wall welded titanium tubes have performed extremely well with neither corrosion nor deterioration of mechanical properties. In the air removal sections of power plant condensers some problems were experienced with galvanic corrosion of the brass tube plates and hydrogen absorption of the titanium tubes. It is claimed that these troubles can be avoided by application of the proper cathodic potential (-0.45 v - 0.7v SCE). Since 1972 some 85000 welded titanium tubes have been operating in blast furnace heat exchangers with no trouble reported.

In condensers with titanium tubes attached to brass plates an increase in the velocity of the seawater coolant increases the rate of galvanic corrosion.

Some titanium tubes have absorbed hydrogen while in service. This is related to the cathodic potential. The hydriding occurs at potentials less than 0.7 (vs SCE) and hydrogen content increases with cathodic potential, as well as with time. There is apparently no problem if the potential of the titanium tube is kept more noble than -0.7V.

The fouling of titanium tubes by marine life is more severe than with copper alloy tube; however deposits are apparently easily removed.

In general the research work at Sumitomo Light Metal Industries is viewed as intensely product oriented but of high quality and of significance both to the scientific and the energy-oriented communities.

SUMITOMO METAL INDUSTRIES, LTD.
AMAGASAKI

George Sandoz

Research divisions were established by Sumitomo Metal Industries as early as 1935 at Osaka Steel Works and the Steel Tube Works. Somewhat later, research divisions were established at the Wakayama and Kokura Steel Works. These were incorporated into the Central Research Laboratories in 1959 and the consolidation of the laboratories at Amagasaki took place the following year. In 1974 the Hasaki Research Center near the Kashima Steel works opened.

The Amagasaki Central Research Laboratories perform work relevant to the company activities, develop new products and processes, and generally promote the use of steel products through technical advances. The Hasaki Research Center is dedicated to steel construction and pipelines, with the capability of full-scale tests.

At the Amagasaki Laboratories the research work is divided into three main areas which cover iron and steel processing, product research and fundamental research. The product research area includes the Mechanical Metallurgy, Applied Mechanics, Chemical Metallurgy, and Welding Sections. Discussions on specific research were held primarily with people in the Mechanical, Metallurgy, and Welding Sections although some other activities in the materials area were discussed generally. A brief account of some general areas of research follows:

(1) Research on the most efficient use of resources and energy. Sintering of ore, use of non-coking coal in the blast furnace, studies of coal-slag-coke reactions in the blast furnace.

(2) Research on steelmaking processes. Techniques of desulphurization, dephosphorization, deoxidation, etc., solidification and continuous casting.

(3) Research in computer control, automatic inspection and quality control devices.

(4) Press formability of steel sheets.

(5) High temperature tube and pipe materials for boilers, chemical industry plants and nuclear power plants. Tensile creep and creep by internal pressure tests.

(6) Research on heat resistant alloys for the high-temperature gas-cooled reactor (HTR). Studies of creep, fatigue and corrosion in helium test loop facility.

(7) Stress corrosion cracking tests of materials for the light water reactor (LWR) in a circulating autoclave system with water at 300°C, 87 atmospheres. Variables which may be controlled are dissolved oxygen, pH, and concentrations of specific anions and cations. Maximum flow rate is 5ℓ/min. Specimens are subjected to tension.

(8) Research on weldability, strength and toughness of high strength steels for ships, bridges, penstocks, line pipe, etc. Studies of microstructure and microalloying.

(9) Welding research with "Gleeble" machine which programs heating, cooling, tension, compression, fatigue and research dilatometric data.

(10) Non-vacuum electron beam welding process. Development for welding of pipes, plates and large scale steel structures.

(11) Large scale closed-loop servo-controlled fatigue tests of welded steel plates, bars, gears, frames, etc. Fatigue crack propagation at high and low temperatures and fracture mechanics analyses.

(12) Delayed fracture studies of high-strength bolts. Large diameter weather resistant bolts with resistance to delayed fracture are claimed to have been developed.

(13) For pollution control, research on the desulphurization and denitrification (removal of S0x and N0x) of stack gases from sintering plants.

(14) Fundamental research on hydrogen embrittlement and stress-corrosion mechanisms in steel, stainless steel and titanium alloys. Instrumentation includes the IMMA, EPMA, SEM, GC-MS and DTA.

In the Mechanical Metallurgy Section Dr. Hiroo Ohtani described work on bainite in low-carbon, low-alloy steels. Three types of bainite are identified according to the morphology of cementite precipitation. Bainite type 1 is formed at 500°C and is carbide free. Bainite type 2, formed at intermediate temperatures, is mainly ferrite laths separated by cementite layers. Bainite type 3 is formed at temperatures near M_s and is characterized by dispersions of cementite in a ferrite lath structure. All these bainite types exhibit the same ferrite habit plane, $\langle 100 \rangle_\alpha \{110\}_\alpha$.

Best combinations of strength and toughness are always found in mixed martensite-bainite structures in low-carbon, low-alloy steels. The toughness of the bainite, however, increases with lower transformation temperature, which reduces the thickness of the ferrite laths, and the bainite type 3 formed near the M_s temperature is tougher than martensite tempered to the same strength level. The duplex martensite plus bainite structure can be further toughened by tempering at 650°C.

The mechanism of toughening of the duplex structure is related to the initial separation of the austenite grains into several parts by the formation of bainite type 3. The "unit crack path" is thus reduced, and toughness is inversely related to this unit length, according to Ohtani and his colleagues. These investigators also show that the transition temperature from ductile to brittle fracture is lowered as unit crack path for cleavage decreases. The concept of unit crack path has been extended to the initiation and propagation of small cleavage areas on {100} planes of ferrite-pearlite and martensite structures in low carbon steels. Thus the overall picture is of a discontinuous cracking process with the toughness related to the population of discontinuities. For greater detail on this work see *Trans Iron and Steel Institute of Japan* **11**, 250, 1971; **12**, 118, 1972; **12**, 146, 1972; **12**, 45, 1972. Also, see *Iron and Steel*, 647, December, 1972, and *Metal Science*, **8**, 357, 1974.

Dr. Minoru Fukuda next described some work to improve steel toughness by microalloying and controlled rolling. This is designed to increase toughness by control over grain size and precipitation hardening. The brittle to ductile transition temperature is also lowered which is of immediate concern for large diameter line pipes.

The "secret" to grain refinement is to provide a large number of ferrite nucleation sites by deforming the austenite below 800°C. Normally the ferrite nucleates at austenite grain boundaries, and this limits the amount of ferrite grain refinement to some fraction of the recrystallized austenite grain size. However, if the austenite is worked at temperatures below 800°C, where recrystallization does not occur, the ferrite may nucleate on deformation bands in the austenite. This produces grain refinement such that ASTM size 10 to 12 may be achieved.

The strengthening effects of V and Nb are complex and vary with the rolling temperature and plate thickness. Precipitation hardening by V raises the transition temperature unless the rolling is finished at 700°C (low temperature). There appears to be no penalty from V or Nb additives with respect to transition temperature if the finishing temperature is low (700°C). For additional information see The Sumitomo Search, No. 9, 8, 1973 and No. 14, 17, 1975.

Another problem with line pipe mentioned by Dr. Fukuda is that of propagation by shear fracture. This must be combated by increasing the fracture tear toughness, which can be done by controlled rolling, decreasing the concentrations of carbon and sulfur and by control over the shape of sulfides. Line pipe must be capable of arresting cracks whereas the welds must only resist crack initiation.

Other work in the Mechanical Metallurgy Section, undertaken to improve production of heavy thick steel plate of 80 kg/mm^2 strength with optimum toughness and weldability, was described by S. Watanabe. Adequate hardenability is promoted by boron additions, but the amount of boron required relates to the levels of nitrogen, oxygen and aluminum. Therefore studies on the morphology of boron compounds in steel and their formation and behavior during rolling, heat treating, etc., have been of interest (See Sumitomo Search, No. 15, 27, May 1976 and *Trans. ISIJ* **15** 637, 1975).

Watanabe and Kunitake have also been studying the formation of austenite between Ac_1 and Ac_3 from the lath ferrites such as low-carbon martensite or bainites. Such transformations give rise to the acicular austenites which are understood for Fe-Ni alloys but not for low-carbon steels.

It has been found that austenite formed from low-carbon steel martensite or bainite laths has the same crystallographic orientation as the laths, the Kurdjomov-Sach relationship. When cementite is involved, the austenite has the same relation to the ferrite and the Pitsch orientation relationship to the cementite. The acicular austenites therefore all have an identical orientation relationship to the lath structure. Upon heating above Ac_3, coarse austenite forms. This austenite consists of several divided regions which correspond to regions of recovered ferrite. These regions are of possible importance in the development of unit cleavage path after subsequent heat treatment and test. Thus these experiments bear on considerations of fracture toughness. Papers on this work appear in *Trans. ISIJ*, **16**, 28, 1976, and in *Proc. First JIM International Symposium* on "New Aspects of Martensitic Transformation," Kobe, 1976.

In the Welding Section Dr. Yoshinori Ito and others described work relative to problems with line pipe welding and with welding thick plate. As always, problems with cracking and fracture toughness are the major concern. The heat affected zones are particularly sensitive. It has been found that managing the levels of alloying elements together with proper rolling and heat treatment procedures can be effective. The silicon level in 60 Kg/mm^2 plate should, for example, be under 0.1 percent, and the ratio of nitrogen to boron should be between 0.25 and 0.5. Representative papers on this work are in Sumitomo Search, No. 6, Nov., 1971; IIW, Doc. IX-576-68; DOC IX-738-71; DOC IX-831-73.

More recently this work has focused on the problem of cracking in the through-thickness direction of thick welded plates. This lamellar tearing is serious in large structures with severe constraints.

The first accomplishment has been the development of steel plates with greater resistance to lamellar tearing. These plates, now available under the trade name SUMI-Z, feature specifications on chemical composition, inclusions and diffusible hydrogen. In addition to control over the ordinary elements (C, Cr, Mo, Si, V, Mn, etc.) it has been found that calcium additions are effective in changing inclusions to a more spherical form. This is called the SCAT (Sumitomo Calcium Treatment) process.

The critical problem with the weld metal is the diffusible hydrogen. Through-thickness cracking is minimized if diffusible hydrogen is very low. Extra low hydrogen electrodes have been developed for thick-plate welding. This work may be reviewed in greater detail in Proc. of the Rome Conference on "Welding of HSLA Structural Steels," Nov., 1976; The Sumitomo Search, No. 13, 8, May, 1975; IIW IX 969-76 and JIW, **46**, 62, 1977.

Another development in the Welding Section has been the use of cellulose coated electrodes for girth welds of line pipe. During welding the cellulose burns and the gas produced keeps oxygen and nitrogen out. The arc is also improved for deeper penetration.

In summary, the research at Sumitomo Metal Industries' Central Research Laboratories is first class, mission-oriented, and offers an excellent example of how scientific research can foster economically desirable ends.

OSAKA UNIVERSITY

George Sandoz

The Departments of Materials Science, Metallurgy, Welding Engineering and the Welding Research Institute at Osaka University, Suita City Campus, complement each other and rather effectively impact the most fundamental metallurgical research investigations on practical metallurgical engineering problems. In this two day period the materials groups (Koza's) dealing with iron and steel (Professor S. Nenno) and metallography (Professor T. Yamane) were visited in the Department of Metallurgy. Professor Y. Mukai's group dealing with stress-corrosion and corrosion fatigue and Professor Y. Kikuta's group which is interested in hydrogen embrittlement and cracking were visited in the Department of Welding Engineering. Professor Fujita was also visited at the world-famous Research Center for Ultra-High Voltage Electron Microscopy in the Materials Science Department. A talk outlining some ONR-NRL research in materials science and engineering, with emphasis on welding, was delivered to the Welding Research Institute. Professor N. Iwamoto who directs the Institute was host.

Professor Nenno's group is studying (1) phase transformations in alloys, (2) structures and mechanical properties of inter-metallic compounds and (3) martensitic transformation and shape memory.

The reverse shape memory (RSM) effect is associated with martensitic transformation and has been observed (1) in beta-brass alloys such as Ni-Ti, Ni-Al, Cu-Zn, Cu-Al-Zn and Cu-Al-Mn and (2) iron-base alloys such as Fe-Mn and Fe-Ni. The RSM effect occurs as these alloys are deformed severely below Ms (or Md). Subsequent heating and cooling then produces spontaneous, reversible and repeatable shape changes in both types of alloys. According to Nenno and his colleagues, deformation induces a stress field into the material which in turn controls the growth directions of the martensitic crystals. Under severe strain these martensites deform by variant-to-variant transformations and upon heating (above A_s) the resultant variants transform to the parent phase, restoring the original shape. This work is described by Nenno and others in a series of papers which continue from 1971 to the present time (See *Scripta Metallurgica* **5**, 663, 1971; **8**, 1055, 1974; **8**, 1363, 1974; **9**, 887, 1975; **9**, 941, 1975). Also *Met. Trans.* **2**, 1487, 1971; *Proc. First JIM International Symposium of* "New Aspects of Martensitic Transformation," Kobe, 1976; *Jr. Less Common Metals*, **50**, 223, 1976. One of Nenno's colleagues, T. Saburi, will work at the University of Illinois during 1977 with Professor C. Wayman, who is also expert on shape memory effects (see *Met. Trans.*, V. **6A**, 29, 1975).

With respect to intermetallic compounds, such as $Ni_3(Al, W)$, there is keen interest in the observation that the yield strength increases markedly with temperature. This phenomenon, which has also been observed in Ni_3Si, Co_3Ti, Ni_3Ga and Ni_3Ge, has been recognized and used in the design of high temperature nickel-base superalloys, but the fundamentals are not well understood. Nenno and his group have conducted compression tests on single crystals of $Ni_3(Al, W)$ to determine the temperature and orientation dependence, and they have found that at low temperatures [111] ⟨110⟩ slips operate whereas at high temperatures [100] ⟨100⟩ slips operate. The positive temperature dependence of the yield strength occurs only over the temperature range of the [111] ⟨110⟩ slips. The peak strength transition temperature between the two slip systems is orientation dependent relative to the compression axis. The critical resolved shear stress of the primary (111)[101] slip also increases as the stress component of the (010)[101] cross slip increases; similar effects are observed with Ni_3Ga and Ni_3Ge. The rate of strength increase with temperature becomes larger as the compression axis approaches the [111] orientation. According to Nenno the probability of the screw dislocations on the {111} slip plane decreases as the deformation temperature increases. The reasons for this reduced mobility are a subject of current investigations. It has been noted that stacking fault energy (SFE) correlates with the difficulty of

cross slip. Papers which describe this and related work in greater detail are published in *Scripta Metallurgica* (**10**, 879, 1976; **10**, 1081, 1976), *Japanese Jr. Applied Physics* (**11**, 437, 1972; **13**, 1461, 1974; **14**, 703, 1976; **16**, 267, 1977) and in *Jr. of Physical Society of Japan* (**32**, 694, 1972; **35**, 1386, 1973; **36**, 1330, 1974).

The group of Professor T. Yamane is interested in (1) fiber reinforced materials, (2) internal friction studies, (3) diffusion in metals and (4) radiation damage in metals. During the initial conversations Yamane noted his extensive work on the physical metallurgy of titanium alloys which terminated about seven years ago, apparently a casualty of the Japanese administrative decision-making process but also the result of Yamane's dissociation from his former employer, Hitachi Shipbuilding and Engineering Co., Ltd., where the titanium work was done.

More recently Yamane and others have specialized in studies of neutron irradiation effects on iron alloys. Of interest is the study of the response of N and C atoms to irradiation, through internal friction measurements. This work has resulted in a long series of papers. The thrust is that C and/or N atoms are trapped by defects produced by neutron irradiation, and released upon annealing at various temperatures. Annealing may take place stepwise with temperature, signaling various events in the release process. The annealing temperatures required for release vary with the composition of the alloy. For instance, carbide stabilizing elements such as Cr and Mo inhibit release of C and N from the radiation-produced C-N-vacancy complexes. The commercial pressure vessel steels ASTM 542 and ASTM A533B have been included in the investigations. Further details may be seen in *Jr. of Nuclear Science and Technology* (**9**, 598, 1972; **10**, 587, 1973; **10**, 556, 1973; **10**, 705, 1973; **11**, 99, 1974; **11**, 114, 1974; **12**, 519, 1975; **12**, 634, 1975). An award for best paper of the year was received in 1976 from the Atomic Energy Society of Japan.

In the field of fiber reinforced materials Yamane's group has studied primarily copper reinforced with W, Mo or Fe fibers. Areas of special interest have been the use of internal friction measurements to study the rolling and annealing characteristics of copper reinforced with Mo and W fibers and the relationships between the mechanical properties and interfacial reaction of composites containing W or Mo fibers in a matrix of copper or copper alloyed with Ni or Mn. The presence of Ni or Mn promotes a reaction zone which may be observed in the microscope and which is tractable to analytical determinations with the electron beam microprobe.

The studies indicate that with respect to strength there is an optimum 5 to 10 microns thickness of reaction zone. These studies are summarized in several papers (see *Proc. 1971 International Conference on Mechanical Behavior of Materials* or Vol. 5, *Soc. of Materials Science* **220**, 1972; *Met. Trans.* 1250, 1974; *Trans. JIM* **13**, 160, 1972; *Trans JIM* **17**, 25, 1976). A somewhat related paper dealing with superplastic deformation in the presence of cross section inhomogeneities appears in *Met. Trans.*, 2159, 1975.

In the Department of Welding Engineering there are continuing studies on the hydrogen embrittlement of base metal and weldments. The researchers employ metallographic and fractographic observations, acoustic emission and internal friction measurements to study hydrogen diffusion and interactions with defects and impurities other than hydrogen.

The work has shown that hydrogen does interact with dislocations and does precipitate at dislocation sites. Plastic strain intensifies the effect of hydrogen and plastic zones attract hydrogen. Kikuta and co-workers see the concentration of hydrogen near crack tips as the indirect result of dislocation multiplication rather than the result of stress concentration. The conclusions are supported by finite element analyses and computer simulations. The substance of this work is described in papers published by the *International Congress on Hydrogen in Metals*, Paris, 1972, pages 144 and 293, IIW Doc. IX-837-73, IIW Doc. II-A-327-73; *Trans. ISIJ* **15**, 87, 1975, *Trans. ISIJ* **15**, 503, 1975; *Nuclear Metallurgy* **20**, part 2, p. 789.

Discussions were also held with Professors Y. Mukai, M. Watanabe and others in the Welding Engineering Department. These investigators have been studying corrosion fatigue (stainless steel and structural steel) and stress corrosion by H_2S (in high strength steels). There were no startling findings reported, but several solid papers have been written (see Technology Reports of Osaka University, **14**, No. 602, 609, 1964; **22**, No. 1040, 155, 1972; **24**, No. 1202, 487, 1974).

Of perhaps greater current interest are some studies in the fracture mechanics of stress corrosion cracking in austenitic stainless steel which Professor Mukai is conducting in collaboration with M. Murata. Using specimens which feature increasing, decreasing or constant stress intensity, the investigators show that substantial differences are seen in plots of da/dt vs. K. If K is decreasing there is a smooth transition between regions I, II and III. In the cases of increasing or constant K, however, there is an abrupt drop in da/dt with increasing K as the boundary between regions I and II is exceeded. Within region II the value of da/dt is fairly constant, but a steady increase occurs again as region III is reached. The investigators at this point associate the "jog" with crack branching. The work is not yet published.

The Welding Engineering Department boasts some massive welding equipment. There is, for example, an electron beam welder of 100 KW and 100 KV accelerating voltage. Welds from 30 to 50 cm. can be made in one pass. New equipment is being obtained which will permit a 300 KV accelerating voltage, and there are plans for a 1000 KW electron beam welder which will weld up to one meter thick.

There is also a 48 KW hydrogen plasma welder and plans for a 100 KW plasma welder which would be the largest in the world.

The Welding Research Institute at Osaka University is distinct from the Department of Welding Engineering. The major contact, Professor N. Iwamoto, and his colleagues have written many research papers over the last three years. Two papers cover oxide inclusions formed in steels by the deoxidizing elements Al, Si, Mn, Ti, V. Nb, Zn and Cr. (See *Trans. JWRI*, **3**, 41, 1974 and **4**, 23, 1975). The different types of inclusions and their morphologies which these deoxidizing elements produce in steel is reviewed.

Iwamoto has also written a series of five papers on slags. First, the basicity of slag is reviewed with respect to concept and effects on solubility of gases such as oxygen, nitrogen and water vapor (*Trans. JWRI* **3**, 89, 1974). A second paper considers the role of CaF_2 in slag and considers the effects of fluorine ions on the Si-O-Si bonds (*Trans. JWRI* **4**, 91, 1975). It is apparently uncertain at this time whether or not fluorine ions break the Si-O-Si bond.

Iwamoto summarizes the structural theory of oxide melts in a third paper (*Trans. JWRI* **4**, 127, 1975). There is still much uncertainty about the structure of the species in molten slags. The meaning of the amorphous state as applied to slags is not clear.

The behavior of amphoteric metal ions such as aluminum and titanium in slag is also described (*Trans. JWRI* **5**, 87, 1976). Again, there is much uncertainty, particularly in the case of titanium, although it is a general view that the ratio of metal to oxide as distributed between metal melt and slag is related to the basicity of the slag. It is therefore remarkable that the rolls of common additives to fluxes such as Al_2O_3, TiO_2 and CaF_2 are so poorly understood.

In the fifth paper on slags (*Trans. JWRI* **5**, 85, 1976) Iwamoto considers gas solubility in slags. It is claimed that there is a strong correlation between the state of aluminum ions in slag and the solubility of gas (water vapor and nitrogen). The role of titanium is not yet resolved.

Because of the interest in amorphous phases in slags, X-ray diffraction studies on amorphous materials are currently active (*Trans. JWRI* **5**, 7, 1976). Determinations of radial distribution functions for Na_2O-SiO_2–GeO_2 glasses were used to infer structure.

A final interest which was discussed with Iwamoto was pressure welding of aluminum to titanium (*Trans. JWRI* **5**, 63, 1976) and diffusion welding of mild steel to aluminum (*Trans. JWRI* **4**, 67, 1975). There has been collaboration with Tokyo Shibaura Electric Co., Ltd., and with Teikoku Piston Ring, Inc., in this work. The results have shown that iron and aluminum form a diffusion bond with Fe_2Al_5 at the interface. With a silver interlayer, Fe_2Al_5 forms at the mild steel side. With a nickel interlayer, Al_3Ni_2 and Al_3Ni form on the aluminum side. Best strength requires a nickel interlayer and vacuum diffusion.

With respect to pressure welding, aluminum is readily pressure welded in air to titanium if the titanium is coated with aluminum by hot dipping prior to welding. The compound Al_3Ti appears at the interface.

The final visit at Osaka University was with Professor Hiroshi Fujita, Director of the Research Center for Ultra-High Voltage Electron Microscopy. The pride of the Center is the 3MV electron microscope which is 10 meters high and weighs 70 tons. Magnification is obtainable from 1000 to 300,000 times with a resolution of about two angstroms. For experimental purposes, several *in-situ* devices are available. Thus metallurgical specimens may be stressed continuously or alternately and at the same time be cooled to the temperature of liquid nitrogen or heated to as high as 1000°C. For studies of superconductivity, a liquid helium device cools to under 4°K; the effects of lattice imperfections on the critical field are of current interest. To study ceramics an electron beam heating device may boost temperatures to 2000°C.

An unusual environmental cell is also available to study biological and metallurgical phenomena as related to the environment. Biological specimens may be viewed *in vivo*. Solid-liquid and solid-gas physical and chemical reactions may be observed. Thus there is a current use of the cell to study hydrogen embrittlement mechanisms.

According to Professor Fujita the principal advantage of the high voltage is that greater specimen thickness can be used. This is important because there are threshold thicknesses below which such material characteristics as dislocation density and recrystallization temperature differ from the bulk material. The high voltage is essential for observation of elements with atomic number over 30.

On the basis of such thickness effect studies, Fujita has concluded that the high strength of whiskers results from their minute thickness. In such thin fibers, dislocations escape at the surface. Whiskers would not be required if the metal could be thinned another way.

The microscope of Fujita has also been used to study sintering phenomena. It has been shown that small particles play an important role in reducing sintering temperature.

Other applications of the microscope are described by Fujita in several recent papers. For applications in materials science see *Japan Jr. of App. Physics*, **11**, 1522, 1972 and *Proc. of the Fourth International Congress on High Voltage Microscopy*, Toulouse, 1975, pages 233, 237 and 345. For studies on deformation see *Jr. Phys. Soc. of Japan*, **40**, 1976, pages 792 and 1103. A paper on diffusion phenomena appears in *Jr. Phys. Soc. of Japan*, **37**, 986, 1974. The universal environmental cell and its applications in metallurgy is described in *Japan Jr. of App. Physics*, **15**, 2221, 1976. The High Voltage Electron Microscope Center has been described also by Dr. Leslie S. G. Kovasznay of ONR Tokyo, who visited Fujita earlier (see *ONR Tokyo Scientific Bulletin*, Vol. 1, No. 2, October to December 1976, p. 27).

The overall impression of Osaka University is entirely favorable. The University is involved in diverse disciplines with a spectrum of activities from theoretical to wholly practical. The extremely gifted and educated investigators work in sufficient proximity that the strength of science is brought to bear on significant problems.

AUSTRALIAN FLUID MECHANICS

Leslie S. G. Kovasznay

INTRODUCTION

Australia is a vast country and a superficial visitor can cover only a small fraction of it. The purpose of my trip to Australia was to attend a meeting and I used the opportunity to visit fluid mechanical activities in a number of cities. In rapid succession, I visited the University of Sydney, the University of New South Wales and made a brief stopover at the Royal Australian Navy Laboratory, all in the greater Sydney area. In all three places I found some interesting fluid mechanics activities. Going on to Canberra, which is the national capital, I called at the Australian National University and paid a brief visit to the Commonwealth Scientific and Industrial Research Organizations (C.S.I.R.O.) Environmental Dynamics Laboratory. Next, of course, was Melbourne with three institutions, the University of Melbourne, Monash University and finally C.S.I.R.O. Laboratory of Atmospheric Physics. The most western stopover was in the city of Adelaide where a strong fluid mechanics group is active. On my return, a brief visit was paid to the University of Newcastle where fluid mechanics is beginning to be active. Unfortunately, I was unable to visit the University of Queensland in Brisbane although I discovered at the meeting attended that there are some interesting activities in progress.

Australia is a large country in area, but still quite small in population. At the time of this trip, I was based in Tokyo and became strikingly aware of the fact that the total population of Australia is only slightly greater than Tokyo proper, and certainly smaller than greater Tokyo if one includes the areas from which people commute to Tokyo daily. On the other hand, most science and most of the economy in Australia are concentrated in the southeastern corner of the country whose area is about the same as Japan. But this is still very thinly populated in comparison to Japan. The two countries contrast in more than one way. One of the important historical aspects of Australia is that it never had a war or revolution; peace and prosperity are the rule. Of course, peace and prosperity are not stimulating enough for competition with other countries. Let's take the cities and institutions one by one.

Sydney, the largest city in Australia, is the center of most economic and cultural activities, even though it is not the seat of the national government. The climate is very pleasant, the seashore is lovely, and several interesting institutions are active. First of all, the University of Sydney is justifiably the pride of the country with a very well appointed campus and prosperity radiating from its buildings and activities.

Fluid mechanics is active primarily in the Department of Mechanical Engineering which of course encompasses many other activities in addition. The chairman of the department, R. I. Tanner, was on an extended overseas leave when I visited so most of my contacts were with Professor R. W. Bilger who is the moving power behind many of its fluid mechanics' related activities. It appears that the University of Sydney recently suffered the loss of two of their internationally known faculty members, one being R. E. Luxton, who became chairman of the department at the University of Adelaide in Southern Australia, and the other, a junior faculty member, R. A. Antonia, who received a professorship at the University of Newcastle. The loss of these two people is still felt although Professor Bilger is compensating for it in vigor and breadth.

The fluid mechanics group has four distinct areas of research interest: (a) jets and flame structure, (b) turbulent boundary layer over a rough wall, (c) wide angle diffusors, (d) refraction and diffraction of shock waves. The first activity, jets and flame structure, is primarily that of Professor Bilger, who has a number of junior research associates exploring several problems ranging from the basic to the applied. On the basic end it must

be mentioned that Bilger was one of the first who seriously adopted the statistical technique that he terms Favre's average. This is a statistical method introduced by Professor A. Favre of Marseille, France, who proposed mass weighted averaging in flows with variable density. These may be either higher temperature heated flows at low speed or strongly compressible flows. Since these flows are usually turbulent when one forms average quantities of the turbulent fluctuations, one encounters certain difficulties as far as the "proper" averaging method is concerned. Favre proposed to average all properties, especially velocity, by multiplying the fluctuations with the instantaneous density, averaging it and then dividing it by the average density. This method "keeps proper account" and Bilger has adopted it when treating his problems in combustion. On the other end of the scale, namely, concrete applications, Professor Bilger made studies of combustion of bagasse which is the fibrous residue from sugar cane, an important by-product of the Australian sugar industry.

The next subject listed is turbulent boundary layer over a rough wall as well as flow in wide angle diffusors. The last item on the list, refraction and diffraction of shock waves as well as stability of flow with shock waves, is directed by Professor L. F. Henderson and the projects are manned by his graduate students. The fluid mechanics group has common interests with other groups too, e.g., Professor Turner's primary interest is rheology, but a secondary interest is computational fluid dynamics, so at this point there is active interaction with other fluid mechanics members of the department. Further interaction with others touches items such as air-sea interaction which involves the Royal Australian Navy and other universities.

Another applied field is parachute dynamics. On one hand it has highly theoretical inviscid flow calculations, but also quite practical tests are being carried out in order to develop appropriate parachute systems. The second Australasian Conference on Heat and Mass Transfer (reported in this issue) was organized by the Sydney group and especially by Professor Bilger and this shows their importance as a group on the whole Australian national as well as on the international scene.

Walking around the campus, accidentally I found another fluid mechanics activity which is of a very applied nature and it must be mentioned here. This is the climatic chamber. In the School of Public Health and Tropical Medicine of the University of Sydney a rather unique facility was established. It is a wind tunnel with variable climatic conditions to test human subjects. It is provided by a variable air flow, with fluctuating temperature and humidity, so human subjects can be routinely tested. It has fully automatic control systems and is used by the above mentioned bio-medical group.

UNIVERSITY OF NEW SOUTH WALES

The university began its existence as an undergraduate engineering school, but in the subsequent development, it became enlarged into a full university. Nevertheless, the engineering flavor is still dominant. The School of Mechanical and Industrial Engineering has about 150 undergraduates and about 30 Ph.D. students. The interest is strongly in applied engineering problems. Professor R. Bryant showed me the facilities. Fluid mechanics in that Department rests primarily with two persons whom I met, Dr. G. L. Morrison, whose interest is computational fluid mechanics, and Dr. J. A. Reizes, whose work is in transport of suspended particles. After seeing the facilities of the School of Mechanical Engineering, I was surprised to find that a very interesting fluid mechanics experiment is being carried out in the School of Mathematics. Within the School of Mathematics, there is a Department of Theoretical and Applied Mechanics where a young faculty member, Dr. M. L. Banner, is doing some quite novel experimental work. The work is aimed at understanding an important phenomenon in air-sea interaction. The problem is the shear stress exerted by the wind on the wave. Theory so far has been a poor guide mainly because the central question is the role that flow separation plays in the problem. Dr. Banner produced an experimental configuration where the wave is stationary. The stationary wave is created by an obstacle in a wind wave flume, where a nearly two-dimensional wave is produced by one or two submerged cylinders. By modifying the configuration of the obstacles, both non-breaking and breaking waves can be created with great reproducibility. The wind flow is counter current and by measuring the velocity profiles of the wind the momentum transferred to the wave can be inferred. Dr. Banner has concluded that the momentum transfer from the wind to the waves critically depends on whether or not the waves are breaking. In breaking

waves the momentum transfer is large, but in non-breaking waves flow separation is absent and the momentum transfer is small.

One more laboratory was visited in the Sydney area, the Royal Australian Navy Research Laboratory, Garden Island, N.S.W. 2000 Australia. It is not far from Sydney, located in a lovely cove. A senior staff member, Dr. Ian S. F. Jones, showed me the interesting research being carried out in an oceanographic fluid mechanics problem. The problem he attacks is the way a shear originating at the surface of the ocean is transmitted through a stably density stratified interface within the ocean. Both laboratory experiments and field observations are being carried out. The laboratory experiments essentially involve repeating, but under better conditions, the original Phillips-Kato experiment carried out at Johns Hopkins University many years ago. The field observations in the ocean are largely dependent on instrument development. Dr. Jones succeeded in developing high sensitivity electromagnetic flow meters measuring velocity fluctuations and also their spatial derivatives. In a typical configuration flow meters are placed separated about one meter apart and the recorded data is "digested" later. The R.A.N. Laboratory provides a very pleasant academic type of working environment enhanced by the fact that Dr. Jones also has close cooperation with academic institutions in the Sydney area.

UNIVERSITY OF NEWCASTLE

The city of Newcastle is located about 100 miles north of Sydney if one travels by road. On the other hand, flying by small commuter airline rewards one with a view of the unusually beautiful coast line, which is full of inlets and islands so it is one of the loveliest scenes anywhere in the world. The city of Newcastle has about 350,000 inhabitants and is the sixth largest city in Australia after the five state capital cities. Basically an industrial city, it is both a busy port, and a center of black coal mining that produces one-half of the Australian total output. Steel industry is also significant, using about 40% of the Australian steel.

The University of Newcastle is located in a residential suburb on an attractive campus. The university is of relatively recent origin, being founded in 1951 as a college of the New South Wales University of Technology. (It became the University of N.S.W. described earlier.) In 1965 it became the full fledged University of Newcastle. My reason for visiting Newcastle was primarily to see Professor R. A. Antonia of the Mechanical Engineering Department in his new academic environment. Professor Antonia was appointed as a professor only very recently (he is relatively young) having worked before as a junior faculty member of the University of Sydney. He has also spent some time at the Imperial College in London with Professor Peter Bradshaw. Professor Antonia is primarily an experimentalist in fluid mechanics and he worked extensively in turbulent flow. He studied turbulence flows of many different kinds; these included the turbulent boundary layer in the wind tunnel where he measured intermittency, used conditional sampling techniques, etc. He also performed experiments in the atmospheric boundary layer where he made measurements with the same care as in the wind tunnel. Several of his papers are described elsewhere in this issue and he is in the process of building up his laboratory at this new university.

MELBOURNE AREA

Greater Melbourne is a large urban agglomeration. The city proper is primarily a harbor surrounded by industrial and commercial areas. It also has a tradition at least on the Australian time scale. There are several academic and research institutions and I had the opportunity to visit three. First was the University of Melbourne. Since my interest was centered around fluid mechanics, my visit was restricted to the Department of Mechanical Engineering and even within the department I concentrated on fluid mechanics. The Department of Mechanical Engineering has a faculty in the order of twenty and fluid mechanics is one of the important pursuits. Two senior people are active in fluid mechanics, Professor P. N. Joubert and Dr. A. E. Perry. In addition several junior faculty members are cooperating. Being an engineering department, the fluid mechanics activity is aimed at some concrete engineering goals such as to improve heat transfer in turbulent boundary layers. Detailed study of velocity and temperature fields was carried out by using modern techniques such as conditionally sampled

bursts of the Reynolds stresses and intermittency phenomena were explored. Special attention was paid to establish scaling laws for the turbulence structures in smooth pipes, and work has been carried out concurrently on rough pipes. Comparison of straight and curved ducts of large aspect ratio was made. A great deal of new information in turbulent flows depends on the refinement of instrumentation especially on the hot-wire anemometer techniques. Thermal effects of the supporting prongs of a hot wire were recently studied. The new popular measuring technique LDV (Laser Doppler Anemometer) is being developed. Since statistical processing is central to many if not most of these experiments, and "an on-line" digital computer was installed, so now conditionally sampled data acquisition and data processing from flow visualization are being developed, the latter with the use of a closed circuit television system.

Because of the interest of the faculty as well as the capability of the equipment, the group headed by Dr. A. E. Perry is in the forefront of the study of the large coherent structures in turbulent flow. On the other hand, Professor Joubert, a senior man with a great deal of experience in shipbuilding and ship shapes, has an interest in problems usually in some way related to navigation. Joubert is an active yachtsman and he participates in international technical meetings in this area. Dr. Perry and his associates have their studies divided in the areas, part on boundary layers and part on pipe flow. These are mostly experimental studies and details of their work that appear to be the most impressive is the way they attempted to reconcile the two presentations, the classical turbulent spectra and the more modern conditional sampling method or truncated signal probability density distributions.

MONASH UNIVERSITY

Monash University is in one of the far suburbs of Melbourne located in a delightful environment and I was able to pay a brief visit. The interesting and surprising finding is that fluid mechanics research is being carried out in the Mathematics Department. Professor Bruce Morton is active in fluid mechanics problems and is conducting some experiments. His interest includes tornadoes and other atmospheric phenomena. He also collaborates with Professor W. H. Melbourne in the Department of Mechanical Engineering. Professor Melbourne developed an active research program on Architectural and Civil Engineering Fluid Mechanics. Locally they refer to the project as "Wind Effects on Buildings and Structures." This includes models of buildings, models of whole city sections, and acoustic tests. The wind tunnel is rather large, and the working area has a 2×1 m cross section with rather long sections. The tunnel is powered by a 400 KW motor that can produce a wind up to 100 m/sec or nearly $M = 0.3$. What makes the work especially interesting is that Professor Melbourne, in addition to conventional engineering testing, did basic fluid mechanics work involving turbulence. He is especially interested in large scale structures and separating flows. He has a recent interesting article in the Proceedings of the Fourth International Conference on Wind Effects on Buildings and Structures, Heathrow (England), 1975 (Cambridge University Press).

In addition to the two teaching institutions in and around Melbourne, a brief visit was paid to the C.S.I.R.O. Division of Atmospheric Physics located in a suburb of Melbourne. The head of the group, Dr. Angus McEwan, showed me around. The most interesting experiment they showed is one on the diffusion of angular momentum and it is claimed that the intensification of cyclone vortex flow can be explained by it. The experiments are being performed in rotating tanks using stroboscopic illumination that facilitates the observation. The development of the vortices is spectacular. I am not a specialist in meteorology but I was quite impressed with the convincing nature of the experiments. The interesting result they obtained is that while in the non-rotating case turbulent motion remains completely random, in a rotating environment the motion organizes into large scale vortices. These appear as lines with excess rotation obtained by merger and intensification of a pattern of vortices thus giving a clue to the development of cyclone patterns. In addition to fluid mechanics, there is extensive solar radiation research and other aspects of atmospheric physics such as internal tides in the ocean, air flow over the mountains, stability of planetary waves, etc.

UNIVERSITY OF ADELAIDE

Adelaide, South Australia, is the farthest south-western point within "Australia's populated corner." Further settlements do not exist much beyond that point. South Australia has charm probably because it was

populated first by free settlers (not by convicts as the rest of continent). Also there was fortunate city planning, so today Adelaide is one of the most attractive cities I ever visited.

The university is in a beautiful setting; it is well equipped and well built, and the city of Adelaide is considered by many as the most progressive community in Australia. The Mechanical Engineering Department is headed by Professor R. E. Luxton who has been Chairman since 1974. Luxton came to Adelaide from the University of Sydney and he has vigorously built up the academic reputation of the department. At the moment the department is organized into five research groups with sufficient overlap to insure cross fertilization. The areas are: (a) acoustics and noise control, (b) fluid mechanics including turbulence and micro-meteorology, (c) thermal energy, (d) bio-engineering including road accident research and (e) systems research. Acoustics and noise control is an active program and Dr. D. A. Bies is pursuing various problems. Presently they are active in acoustic holography in sound propagation in ducts, sound radiation from pipes, jet flow, vibration and energy coupling in buildings and similar structures, laser doppler velocity meter, etc.

Fluid mechanics is strongly dominated by an interest in turbulence. Besides Professor Luxton, Dr. Garry L. Brown, currently a reader, is the outstanding researcher in the field. The name of Brown is well known from the beautiful experiments he conducted in cooperation with Professor A. Roshko at California Institute of Technology. Recently Brown had developed his own operation in Adelaide which would be a credit to any of the best institutions. The work of the two-dimensional shear layer with the mixing of two different gases is well known. The most recent work of Brown is related to the problem of large scale structures in the turbulent boundary layer carried out in collaboration with A.S.W. Thomas. They were able to make refined measurements involving correlation between a surface hot-film probe and another hot-wire anemometer placed at different distances from the wall. The conclusions they reached are very interesting. They claim that they attempt to account for the bursting phenomenon near the wall by demonstrating that the slowly varying wall shear imposed by the large structure gives rise to sufficient streamline curvature in a study of flow coordinate system aimed to produce a TAYLOR-GOERTLER type of instability. It was shown that this instability may be centered at a distance from the wall of the order of $y_+ = 50$, so that the streak spacing founded by earlier authors amounting to 100 wall units is not inconsistent with the model. This is the first attempt that appears to explain successfully how the large scale motion creates a feedback on the bursting phenomenon and maintains the cycle of the tour. The paper is soon to appear in the technical literature. Continuing with the department, there is a great deal of activity by Professor Luxton to secure a broader base for the department both financially and with industrial relations. He appears to be successful in bridging the gap between basic research and community oriented applied research. It is my estimate that the importance of the Center will increase in the forthcoming years especially if they can continue to attract and retain high caliber people like Dr. Brown.

CANBERRA

The city of Canberra is the Federal Capital of Australia. It was founded in 1911 as a planned community. In this way, it resembles an earlier example of Washington, D. C., or a later example, Brasilia in Brazil. It was designed for 2,000,000 people and was chosen at a location that is 322 km from Sydney and 644 km from Melbourne. Both the sea and the nearby mountains are within a reasonable driving distance. It is a well thought out community with ample territory for expansion.

In this environment in 1946 there was created, by the act of Parliament, a research university which in 1960 was enlarged. It became a full university called the Australian National University by adding the undergraduate schools. The university consists of two intertwined components; one is called the Institute for Advanced Studies and the other is the School of General Studies. The Institute for Advanced Studies has only graduate students and about one-half of them are from overseas. The School of General Studies has about 5,000 undergraduates within five faculties. These are Art, Asian Studies, Economics, Law, and Science. The Institute for Advance Studies has seven large research schools: Biological Sciences, Chemistry, Art Sciences, The John Curtin School of Medical Research, Pacific Studies, Physical Sciences, and Social Sciences. There are no undergraduate students and there are about 350 graduate students, most of them working for the degree

of Doctor of Philosophy, the majority of them holding research scholarships awarded by the university. What makes the foreign visitor somewhat confused is that the School of General Studies also has developed some graduate education and now they have 700 graduate students, about 200 for the Ph.D. and 500 "Masters Qualifying." In addition, the University has multi-disciplinary research centers such as Center for Resource and Environmental Studies, Humanities Research Center, Contemporary China Center, and North Australia Research Units. The latter one is focusing on the problems especially interesting to Australia and in general for tertiary education. The term is used to cover college age education.

My primary interest in going to Canberra was to visit the Earth Science Research School, Geophysical Fluid Mechanics activity, especially Professor J. S. Turner who is an internationally known specialist. Professor Turner was lured back to Australia less than two years ago from Cambridge University where he became known for his ingenious geophysical fluid mechanics experiments. He is an Australian by birth and welcomed the opportunity to return to his native land in an attractive setting; to have good research opportunities he set up an experimental laboratory at the Australian National University. I spent one afternoon in his laboratory watching with great fascination his experiments on double diffusion. He has established a sugar-salt system, and a shadowgraph photography is used for visualization. Turner takes still photographs as well as time lapse movies to explore various situations of increasing complexity. The double diffusive phenomenon is compared with the less complex situation when a simple source of salt solution intrudes horizontally as a thin layer at its own density level into a salinity gradient. On the other hand, if the injected salt solution is replaced by a sugar solution with a matched density into the same salinity gradient, the injection is soon followed by spreading at several levels. The extending "noses" have a sharp diffusive interface on the top and a fan of fingers resembling the so called "salt fingers" underneath and they all move up at a small angle. At the same time, a strong internal shear is set up by convection clearly demonstrated if one places vertical dye streaks into the tank. The phenomenon is fascinating and Professor Turner spent a great deal of effort clarifying it. Turner is likely to develop an important school of Geophysical Fluid Mechanics, because he already had great influence in Cambridge, England. But at the moment, he is still in the early stages of building up his laboratory.

Turning now to the Physics Department I was pleasantly surprised to find a real fluid mechanics activity there in the person of Professor H. G. Hornung. His interest is mostly in ionization of gases and shock waves, and he has a number of publications to his credit in the field. They do measurements on ionization and dissociation of gases because it affects the behavior of shock waves, or reading it in the reverse way, they learn about ionization and dissociation processes by studying the behavior of shock waves. Outside of these two activities, there is not much fluid mechanics research at the university.

C.S.I.R.O. DIVISION OF ENVIRONMENTAL MECHANICS, CANBERRA

C.S.I.R.O. has a large network of laboratories throughout Australia and a relatively small group is located in Canberra. The Director of the group is Dr. J. R. Philip. He is well known in the United States. With his associates, especially with Dr. E. F. Bradley, P. G. Mulhearn, and P. W. Ford, I was given a conducted tour of the facilities. Of course, environmental interests dominate. Radiation balance, plants environment as well as wind tunnel simulation and other activities give a small but varied program. The laboratory was a gift of Mr. S. C. Pye and was opened in 1966. A handsome small building houses everything and the most important facility shown to me was the wind tunnel. It has a very large working section and it is more like a long channel, in which different kinds of environmental conditions can be simulated. Examples of rough surface simulate plant cover or a snow fence. Picking up and depositing snow is simulated too. A plant canopy is simulated by a "fully developed" turbulent boundary layer and all these were under active study. It was very gratifying to see how well a small scale independent government laboratory can operate in a rather academic fashion pursuing research that ranges from highly practical down to the basic types. This observation was further reinforced in Melbourne where another group was pursuing similar activities. It is clear that Canberra, the national capital, besides being the political center of Australia, begins to have some serious research activities, at the moment still scattered, that are likely to be built up in the foreseeable future.

SECOND AUSTRALASIAN CONFERENCE ON HEAT AND MASS TRANSFER THE UNIVERSITY OF SYDNEY, AUSTRALIA FEBRUARY 16-18, 1977

Leslie S. G. Kovasznay

This being the second conference on the subject, it is hoped that it will become established as a regular event in Australia. The conference covered a wide range of topics in heat and mass transfer. These began with geophysical and engineering applications, and there were also some with biological relevance. There were a total of 66 papers including one opening plenary lecture by Professor J. S. Turner of the Australian National University, who spoke on various applications of double diffusive convection. There were also three special review papers. The first was by E. K. Webb, C.S.I.R.O., Aspendale, who spoke on convection mechanisms of atmospheric heat transfer from the surface to global scales. The second was by Leslie S. G. Kovasznay, ONR Tokyo (on leave of absence from Johns Hopkins University), on coherent structures in turbulent shear flows. The third was by Stephen Whitaker, University of California, Davis, on drying in porous media. The remaining contributed papers were divided into 12 sessions organized in such a manner that there were always two parallel sessions.

Geophysical system (2 sessions)
Boiling and condensation (2 sessions)
Natural and forced convection (2 sessions)
Multicomponent-multiphase transfer
Wetting and drying of porous media
Colloquium on artificial kidneys and blood dynamics
Systems with chemical reactions
Biological systems
Radiation and conduction

The professional interests of the speakers were distributed in the following order: mechanical engineering, chemical engineering, atmospheric sciences, bioengineering, etc.

The conference, of course, was organized by a committee, but the actual work fell mostly on the shoulders of R. W. Bilger of the Department of Mechanical Engineering of the University of Sydney. Registered attendance was in the order of 150 persons with some unregistered who were mostly students from local institutions. The time of the meeting was chosen to be in mid-February, a little before the beginning of the fall semester. The weather was that of late summer corresponding to what one might find in early September in the middle Atlantic states in the United States. The subject matter of the papers represented a truly wide spectrum. It ranged from basic scientific research problems all the way to some very concrete and specific applications, including such titles as "Heat Transfer of Cattle and Significance in Animal Production" and "Drawing of Optical Fibers Using Intense Laser Heat Source." It is impossible to do justice to all of the topics in a short summary, but a few examples may convey the flavor of the meeting.

The opening lecture by J. S. Turner was given as a "conducted tour" through double diffusion phenomena. Of these the so-called "salt fingers" are best known. The term double diffusion refers to a situation when two different transportable quantities affect the density of the fluid and they diffuse at different rates. In an apparently stable stratification (lighter fluid on top) one may be surprised by rather spectacular patterns. In the case of the classical salt fingers, salinity and heat are the two diffusive quantities and they were explored. In addition there are other systems of which Turner favors the one consisting of salt and sugar solutions. Turner showed a large number of samples of configurations taken in his laboratory in Canberra.

The special review paper of E. K. Webb dealt with the "dry" heat transfer, more specifically with those processes that do not involve the latent heat of the water content. The problems treated included the surface layer, the convective boundary layer, the "thermals" and finally the global pattern that provides the poleward heat transfer, at least for middle geographical latitudes.

The special review paper by L. S. G. Kovasznay gave an overview of the new trend in turbulence research, namely, the discovery of the importance of large scale coherent structures in turbulent shear flows. These findings may have important implications for the heat and mass transfer.

In the third special review paper S. Whitaker dealt with drying in porous media. He offered what he terms as a "rational route to a set of equations describing the transport of mass and heat in porous media."

As not too many copies of the proceedings will find their way to the United States I reproduced here the titles, authors, their affiliations for all papers, including some brief comments.

OPENING PLENARY LECTURE

1. *Various Applications of Double-Diffusive Convection*
   J. S. Turner
   Australian National University
   Canberra, A. C. T. 2600

SPECIAL REVIEW PAPER

2. *Convective Mechanisms of Atmospheric Heat Transfer from Surface to Global Scales*
   E. K. Webb
   C.S.I.R.O., Atm. Phys., Aspendale, Victoria 3195

3. *Coherent Structures in Turbulent Shear Flow*
   L. S. G. Kovasznay
   ONR Tokyo (on leave from Johns Hopkins University, Baltimore, MD 21218)

4. *Drying in Porous Media*
   S. Whitaker
   Dept. of Chemical Engineering, University of California, Davis, CA 95616

GEOPHYSICAL SYSTEMS

5. *Correction of CO_2 Transfer Measurements for the Effect of Water Vapour Transfer*
   E. K. Webb and G. I. Pearman
   C.S.I.R.O., Atm. Phys., Aspendale, Vic. 3195

6. *Coupled Transports Across a Diffusive Interface*
   P. F. Crapper
   University of Cambridge, England
   (presently, C.S. I.R. O., P.O. Box 1666, Canberra, A. C. T. 2601)
   Both free convection and forced convection driven by oscillating grid were studied, following the technique introduced by Turner.

7. *On the Transfer of Airborne Pollutants in an Area with Broken Topography*
   W. W. Moriarty
   Bureau of Meteorology, Box 1289K, Melbourne, Vic. 3001
   Detailed numerical calculations in the Albury Wodonga area.

8. *A Model Problem Related to Thermal Pollution*

V. S. Paparo
Dept. of Mathematics, University of Western Australia, W. A. 6009

Axisymmetric flow model is bounded by two parallel horizontal plates. Point heat source is on lower plate, distributed heat sink on upper plate. Asymptotic behavior is determined.

9. *The Role of Latent Energy for Convective Heat Transport in the Atmosphere*

W. R. Kininmonth
Bureau of Meteorology, Melbourne, Vic. 3002

A numerical simulation.

10. *The Interaction of Cumulus Convection with a Large-Scale Atmospheric Model*

J. L. McGregor
Australian Numerical Meteorology Research Centre
P. O. Box 5089 AA, Melbourne, Vic. 3001

A numerical prediction scheme for Australian conditions.

11. *The Influence of Summer Ground Radiative Heating on Numerical Weather Prediction*

L. M. Leslie and D. J. Gauntlett
Australian Numerical Meteorology Research Centre
P. O. Box 5089 AA, Melbourne, Vic. 3001

12. *Structure of Temperature and Velocity Fluctuations in the Atmospheric Surface Layer*

R. A. Antonia
Dept. of Mechanical Engineering, University of Newcastle

Author reports experimental determination of the "one-point" statistics of the velocity and temperature fluctuations in the atmospheric boundary layer. Comparison with Gaussian or with joint-Gaussian distributions shows rather good agreement for the velocity, but poor agreement with temperature fluctuations' probability density function.

BOILING AND CONDENSATION

13. *Interphase Mass Transfer in Evaporation*

S. H. Algie
Dept. of Mining and Metallurgical Engineering
University of Queensland, St. Lucia, Qld. 4067

One part is a theoretical assessment of the Hertz-Knudsen equation and a correction factor is suggested. Other part examines the evaporation from spherical droplets into non-condensing gases and author recommends Fuchs' approach.

14. *A New Approach to Convective Heat-Transfer Correlations*

D. G. Evans
Department of Chemical Engineering
University of Melbourne, Parkville, Vic. 3052

Author is pleading for standardized data of correlations from the experimenters in order to benefit the designers.

15. *The Temperature Field Surrounding an Equilibrium Water Vapour Bubble on a Heated Surface*

J. D. Waters, Dept. of Mechanical Engineering,
Royal Melbourne Institute of Technology and
R. Gani, Mechanical Engineering Dept.,
Monash University, Clayton, Victoria

Careful experiments were conducted on the underside of a heated plate. Visual observations of the bubble shape as well as temperature measurements by thermocouple established the detailed temperature field and comparison was made with existing theory.

16. *Two-Phase Liquid-Liquid Flow in a Vertical Eccentric Annulus*

P. L. Spedding and L. A. Husain
Dept. of Chemical and Material Engineering, University of Auckland, New Zealand, and
P. M. C. Lacey
Dept. of Chemical Engineering, University of Exeter, U. K.

Oil water system. Experiment was motivated by the "burn out" or "critical heat flux" phenomenon.

17. *Two-Phase Fluid Mechanics and Heat Transfer in the Dry Wall Region*

D. R. H. Beattie
Australian Atomic Energy Commission Research Establishment, Lucas Heights, N.S.W. 2232

Engineering parameters were predicted by a consistent calculation method.

18. *An Experimental and Theoretical Analysis of Void Fraction Dynamics in a Boiling Channel*

T. M. Romberg
Australian Atomic Energy Commission Research Establishment, Lucas Heights, N.S.W. 2232

Cross correlation and power spectrum are used in the statistical description and input-output functions. They are defined by borrowing the techniques of noise analysis.

19. *Effect of Air Content and Mass Inflow on the Pressure Rise in a Containment During Blowdown*

J. Marshall and P. G. Holland
Australian Atomic Energy Commission Research Establishment, Lucas Heights, N.S.W. 2232

Experiments and calculations concerning the processes occurring at rapid "blow down" of a pressure vessel. The application is to estimate the behavior of a nuclear power reactor when there is a sudden rupture in the coolant circuit.

20. *Filmwise Condensation of a Pure Substance Inside a Horizontal Tube*

K. L. Nguyen and D. G. Wood
Dept. of Chemical Engineering, University of Melbourne, Parkville, Victoria 3052

Proposes theoretical model and reports some experiments with Freon 113.

NATURAL AND FORCED CONVECTION

21. *Heat Flux Balance in a Turbulent Boundary Layer*

H. Q. Danh
Dept. of Mechanical Engineering, University of Sydney, N.S.W. 2006 and
R. A. Antonia, University of Newcastle, N.S.W. 2308

A well conceived and carefully executed experimental paper giving the one-point double correlations of the velocity and temperature fluctuation fields. It enables one to assess the heat flux budget in order to check the calculation methods of different authors (e.g., Donaldson or Lumley).

22. *An Experimental and Numerical Study of Developed Single Phase Axial Turbulent Flow in a Smooth Rod Bundle*

J. D. Hooper
Australian Atomic Energy Commission, Research Establishment, Lucas Heights, N.S.W. 2232

Experiments are reported to support a calculation scheme for predicting velocity distribution and shear stress.

23. *The Effect of Return Bends on the Heat Transfer From an Internally Flowing Turbulent Air Stream in Smooth Tubes*

R. J. Batterham
C.S.I.R.O., Division of Chemical Engineering, Clayton, Victoria and
D. G. Wood
Dept. of Chemical Engineering, University of Melbourne, Parkville, Victoria 3052

Engineering data was obtained.

24. *Natural Convection in Inclined Hemispherical Cavities – An Application in Pyranometry*

A. Cabelli

Division of Mechanical Engineering, C.S.I.R.O., Highett, Vic. 3190

Numerical solutions were obtained in a closed hemispherical space heated by an isothermal disk at the base.

25. *The Development of Laminar Natural-Convective Flow Through an Inclined Parallel-Plate Duct with Uniform-Temperature Heating*

G. McDonaugh and J. R. Dyer

Mechanical Engineering Dept., University of Adelaide, S. A. 5001

Numerical solutions for different Raleigh numbers are presented.

26. *Transient Free Convection Heat Transfer Between a Heating Coil and Liquid in a Cylindrical Vessel*

D. S. Langford and I. H. Lehrer

Dept. of Chemical Engineering, Monash University, Victoria 3168

Experiments were made both with water and glycerol.

27. *Free Convection Heat Transfer to Liquid Metals in Vertical Annuli*

C. R. Vijayasimha, K. K. Vasu and V. G. Kubair

Indian Institute of Science, Bangalore 560012, India

Solutions based on the boundary layer equation were obtained for a range of Prandtl numbers and Grashof numbers and ratios of the radii.

28. *Transient Free Convection From a Suddenly Heated Horizontal Wire in a Small Enclosure: Numerical Investigation and Holographic Visualization*

G. Antonini, P. H. Dantan, and G. Guiffant

L.B.H.P. University of Paris VII, 2 Place Jussieu 75005 Paris, France

A finite wire placed in a rectangular box is heated suddenly. Numerical calculations as well as interferrometric flow visualization are carried out and empirical formulae are suggested.

29. *Confirmation and Interpretation of a Kink in the Nu (Re) Plot for a Cylinder in a Transverse Stream*

R. G. Wylie and T. Lalas

National Measurement Lab., C.S.I.R.O., Sydney, N.S.W. 2008

Local heat transfer rates were carried out based on the evaporation rate of solid para-dichlorobenzene. The most important result is that the "kink" is most prominent at the rear stagnation point.

30. *The Frequency Response of Hot-Wire Anemometer Sensors to Heating Current Fluctuations – An Intriguing Boundary Value Problem*

K. Bremhorst and D. B. Gilmore

Dept. of Mechanical Engineering, University of Queensland, St. Lucia Q4067, and

L. Krebs, Ges. Kernforsch Inst. Reaktorbau, 75 Karlsruhe, Germany

Authors found that under low overheat and large end loss conditions a single time constant is insufficient to describe the response, so new equation is proposed.

31. *The Effect of Electrical Corona on the Natural Convective Heat Transfer From a Circula Cylinder in Air*

V. T. Morgan and R. Morrow

National Measurement Laboratory, C.S.I.R.O., Sydney, N.S.W. 2008

Nusselt number increases abruptly at onset of corona.

32. *Practical Considerations in the Selection and Design of Heat Exchangers*

J. Marek

ICI Australia Engineering Pty Ltd., Melbourne, Victoria 3001

MULTICOMPONENT/MULTIPHASE TRANSFER

33. *Heat and Mass Transfer in Regenerators*

J. G. Van Leersum
University of Western Australia, W. A. 6009, and
C. W. Ambrose
Dept. of Mechanical Engineering, Monash University, Clayton, Vic. 3168

Paper deals with regenerators in which condensation occurs. Equations are derived; calculations were carried out and tests were performed in experimental apparatus.

34. *Melting of a Single Body in a Hot Gas Stream*

J. E. Rowney and D. G. Wood
Dept. of Chemical Engineering, University of Melbourne, Vic. 3052

Equations are derived for spherically symmetric melting problem. Experiment consists of melting wax sphere in hot air stream.

35. *Assessment of Cooling Systems Using Approximate Methods*

P. Bath
School of Nuclear Engineering, University of New South Wales, Kensington, N.S.W. 2033

36. *Practical Simulation of the Wet Flat Plate for Absolute Psychrometry*

R. G. Wylie and T. Lalas
National Measurement Lab., C.S.I.R.O., Sydney, N.S.W. 2008

Critical analysis of flat plate and wedge shaped psychrometer.

37. *Mass Transfer in the Spray Regime on an Industrial Sieve Tray*

N. T. Hai, J. M. Burgess, W. V. Pinczewski and C. J. D. Fell
School of Chemical Engineering, University of N.S.W., Kensington, N.S.W. 2033

Important differences were found between operations in the "spray" regime and "froth" regime.

38. *The Occurrence of Bubbling in Gas Desorption From Solution*

L. T. Thuy and R. H. Weiland
Dept. of Chemical Engineering, University of Queensland, St. Lucia, Queensland

It is concluded that in a flow system effective bubbling begins only when the partial pressure of the dissolved gas alone exceeds the ambient pressure.

39. *Bubble Growth During Stream Degassing*

S. Mizoguchi, D. G. C. Robertson and A. V. Bradshaw
Dept. of Metallurgy and Material Sciences, Imperial College, London, England

Liquid silver jet with oxygen bubbles has divergent cone shape due to bubble nucleation and growth.

40. *Mass Transfer Studies in Particulate Systems Using the Population Balance Approach – The Growth of Gypsum Crystals*

E. T. White and L. T. Hoa
Chemical Engineering Dept., University of Queensland, St. Lucia, Queensland

A refined technique using detailed mass distributions statistics.

WETTING AND DRYING OF POROUS MEDIA

41. *The Continuous Drying of an Ideal Moist Solid*

R. B. Keey
Dept. of Chemical Engineering, University of Canterbury, Christchurch, N. Z.

Analysis and discussion of the industrially important problem.

42. *A Closed Loop Optimum Controller for Diffusive Drying*

P. F. Lesse and M. Kovarik

Division of Buildings Research and Division of Mechanical Engineering

C.S.I.R.O., Highett, Victoria 3190

Mathematical model for numerical calculations.

43. *Moisture Levelling in the Radio-Frequency Drying of Green Beech Timber*

R. Morrow

National Measurement Lab., C.S.I.R.O., Sydney, N.S.W. 2008

It provides information for design of drying processes.

44. *Experimental Study of Wetting Front Instability in Porous Media*

I. White, P. M. Colombera and J. R. Philip

Division of Environmental Mechanics, C.S.I.R.O., Canberra, A.C.T. 2601

Hele-shaw cells were used with two liquids, comparison with Philip's theory given.

45. *Heat Transfer and Thermal Effects in Heated Cylinders of Victorian Brown Coal*

B. R. Stanmore and A. R. Boyd

Dept. of Chemical Engineering, University of Melbourne, Parkville, Victoria 3052

ARTIFICIAL KIDNEYS AND BLOOD DYNAMICS

46. *Dialysis Therapy Guided by Kinetic Modelling: Applications of a Variable-Volume Single-Pool Model of Urea Kinetics*

P. C. Farrell

Biomedical Engineering, University of N.S.W., Kensington, N.S.W., and

F. A. Gotch

Franklin Hospital & University of California, San Francisco, California

Improvement of dialysis therapy by monitoring treatment by computer controlled operation.

47. *Convective Mass Transfer in the Artificial Kidney*

K. Schindhelm and P. C. Farrell

School of Chemical Engineering, University of N.S.W., Kensington, N.S.W. 2033, and

J. H. Stewart

Medical Research, Sydney Hospital, N.S.W. 2000

A mathematical model is proposed for the prediction of the mass transfer rate.

48. *The Effects of Ultrafiltration on the Clearance of a Hemodialyzer with a Recirculating Single Pass Dialysate Mode*

R. P. Popovich and J. S. Ng

Biomedical Engineering, University of Texas, Austin, TX 78712, and

J. W. Moncrief, J. F. Decherd and S. Morris

Austin Diagnostic Clinic, Renal Outpatient Center, Austin, TX 78705

Theory supported by one experiment using tritium tagged vitamin B-12.

49. *Development of a Sorbent-Based Wearable Artificial Kidney*

P. C. Farrell, P. W. Hone, R. A. Ward and P. E. Abernethy

Biomedical Engineering & Chemical Engineering, University of N.S.W., Kensington, N.S.W. 2033, and

J. F. Mahony

Renal Unit Sydney Hospital, Sydney, N.S.W. 2000

In vitro evaluation with short term clinical experience.

50. *Capillary Blood Cell Movement – A Biological Case of Elastic Behaviour in Capsule Flow*

P. S. Lingard

Research Unit for the Newborn, Women's Hospital, Crown St., Sydney, N.S.W. 2010

The capillary rheology of red blood cells was studied using a high precision rheometer.

51. *Preliminary Verification of the Low Dialysis Clearance Hypothesis Via a Novel Equilibrium Peritoneal Dialysis Technique*

R. P. Popovich and W. K. Pyle
Dept. of Chemical & Biomedical Engineering, University of Texas, Austin, TX 78712, and
J. F. Decherd and S. Brooks
Austin Diag. Clinic, Renal Outpatient Center, Austin, TX 78705

A new low clearance equilibrium dialysis technique is discussed. It is ambulatory, easy to perform, does not require blood or machine access, and results in stable, low metabolite levels.

SYSTEMS WITH CHEMICAL REACTION

52. *Predictions and Measurements in Turbulent Buoyant Diffusion Flames*

M. Glass and J. H. Kent
Dept. of Mechanical Engineering, University of Sydney, N.S.W. 2006

Mean velocity and turbulent fluctuations were measured by LDV (Laser Doppler Velocimeter) and the results are presented in terms of "Favre averaging."

53. *The Prediction of Radiative Transfer in Utility Furnaces by Computer Simulation*

T. F. Wall
Dept. of Chemical Engineering, University of Newcastle, N.S.W. 2308, and
K. K. Boon
Electricity Trust of S. A., Eastwood, S. A. 5063

Computer simulation of the performance of boilers fired by pulverized coal.

54. *The Combustion of a Wet Cellulosic Fuel Bed*

B. W. Lamb and R. W. Bilger
Dept. of Mechanical Engineering, University of Sydney, N.S.W. 2006

The combustion of bagasse (sugar cane fibre) was studied in a laboratory furnace. Reproducible results were obtained showing the dominance of convective heat and mass transfer processes.

55. *Decarburization Reaction Model*

K. Grezl and N. A. Molloy
Metallurgy Dept., University of Newcastle, N.S.W. 2308, and
J. M. Burgess
Central Research Lab., B.H.P. Co. Ltd., Shortland, N.S.W. 2307

56. *Determination of Kinetic Parameters for Enzyme Systems – Detection and Measurement of Mass Transfer Resistance*

P. F. Greenfield
Dept. of Chemical Engineering, University of Queensland, St. Lucia, Queensland 4067

57. *Mass Transfer Considerations in Large Scale Fermentations*

P. P. Gray
School of Biological Technology, University of N.S.W., Kensington, N.S.W. 2033

BIOLOGICAL SYSTEMS

58. *Prediction of the Surface Seedbed Environment of a Pasture in a Dry Monsoonal Climate*

G. McKeon
Griffith University, Nathan, Queensland 4111, and
J. D. Kalma
Land Use Research, C.S.I.R.O., Canberra, ACT 2601

Prediction of surface temperature and moisture from standard meteorological observations in a dry monsoonal climate using a one-dimensional energy budget model is described.

59. *Estimation of Radiation Environments in Row-Planted Communities by a Leaf Geometry Model*

S. Fukai and L. Davison
School of Biological Science, Macquarie University, North Ryde, N.S.W. 2113

A simulation model to estimate radiation in row-planted crops was presented.

60. *Oxygen Transfer Across the Mud Water Interface*

H. P. Hudson, T. Duxbury and Y. T. Tchan
Dept. of Microbiology, University of Sydney, N.S.W. 2006

The main conclusion is that hydrocarbon content did not affect greatly the oxygen intake by bottom sediments.

61. *A Two Layer Model for Momentum Fluxes at Vegetated Surfaces*

D. J. Hasick
School of Biological Science, Macquarie University, North Ryde, N.S.W. 2113

The model for transfer of mass, momentum and heat was applied to an ATRIPLEX Community near Broken Hill.

62. *Heat Transfer of Cattle in Warm Natural Environments: Its Significance in Animal Production*

J. C. D. Hutchinson
Division of Animal Production, C.S.I.R.O., Blacktown, N.S.W. 2148

Heat transfer is important due to the loss of protein and phosphorus by sweating in hot semi-arid regions.

RADIATION AND CONDUCTION

63. *Materials Problems in Evacuated Solar Energy Collectors*

D. Campbell, G. Harding, D. McKenzie and B. Window
School of Physics, University of Sydney, N.S.W. 2006

Emphasis is on outgassing and selective surface degradation.

64. *Thermal Emissivity Measurements on Various Materials, in Particular Aluminium Subject to Surface Conditions Which Include Some Oxidation*

W. J. Green
Australian Atomic Energy Commission, Research Establishment, Lucas Heights, N.S.W. 2232

65. *Drawing of Optical Fibres Using an Intense CO_2 Laser Heat Source*

K. Jueloep
Laser Group, W.R.E., Salisbury, S. A. 5108

Experimental results are given on a system using a 90 watt CO_2 laser to draw optical fibers.

66. *A Simple Model of Transient Heat Transfer and Its Application to Power Excursions in Water Moderated Nuclear Reactors*

J. W. Connolly
Australian Atomic Energy Commission, Research Establishment, Lucas Heights, N.S.W. 2232

A computation model was developed that describes satisfactorily the power behavior observed.

67. There was a paper not listed, neither in the program nor in the proceedings:

I. A. N. Jones
R.A.N. Research Laboratory, Sydney.

Title is *Project Bass Transport Across Sea Surface.*

Author developed a model of the transport across sea surface when there is a boundary layer both in the sea and in the air. Experiments were carried out from an oil drill platform.

THIRD INTERNATIONAL CONFERENCE ON PRESSURE VESSEL TECHNOLOGY

L. E. Steele

This third of a series of international conferences known by the acronym, ICPVT, follows the pattern established in Delft, Netherlands, in 1969 when the first such conference was held. The basic purpose of the conferences was to provide a forum for pressure systems specialists from around the world to review advances which had been made in the use of pressure vessels in various high technology fields, especially chemical, nuclear, marine, and space applications. Emphasis is placed on analysis, design, and inspection as well as materials fabrication and the evaluation of materials in service, and by all measures the conference was a success.

Following the tradition of past conferences, two volumes of proceedings are published before the conference and one after. The first for the Third ICPVT is entitled, "Analysis, Design, and Inspection," in this case, and the second, "Materials and Fabrication." A third will include the invited papers as well as discussion recorded as the papers were presented.

Emphasis in this third conference has included as a significant component, inspection, whereas in the past emphasis was on design and analysis and, separately, on materials and fabrication. The make-up of the conference was tailored to attract as many non-Japanese papers as possible, making it difficult for all submitted Japanese papers to be included. Nevertheless, the list of papers provides a useful sampling of research conducted in Japan as well as in other nations.

The theme and the importance of the conference was established by the opening addresses by Professor H. Kihara and Professor S. Kawa. Professor Kihara, University of Tokyo, cited the significant changes in the world which have occurred since the prior meeting in San Antonio in 1974. He called attention to the critical importance of pressure vessel technology in assuring more efficient and reliable systems for energy conversion especially, as well as for industrial processes. A similar emphasis on advanced energy systems was cited by Professor Seiji Kaya, President of the Japan Society for the Promotion of Sciences. He called attention to the necessity for advancing "inexhaustible" energy supplies, as in the case of nuclear fusion, pointing out the problems which will occur in that special kind of environment in which thermal cycling will create enormous problems for the first wall or primary system boundary of fusion reactors when developed. The high level of attendance with four simultaneous sessions covering three and a half days is testimony to the attitude in Japan towards the importance of the technology of high pressure.

Some critical problems of the future were described in the plenary session which covered the impact of computers on pressure vessel technology and the problems of materials quality and degradation of materials in service along with the problem of designing to consider seismic problems.

The author's primary interest was in materials and mechanical properties aspects of the conference, consequently, the necessity for attending the sessions of primary interest precluded significant attendance at the sessions on analysis, design and inspection.

In the area of materials and mechanical properties, the primary emphasis was upon fracture and fatigue, these being two critical factors in assuring no catastrophic failure in these systems or no failure which would cause a significant loss of "on-line" service for systems usually involving high temperature, high pressure operation.

The many papers on fatigue covered generally the topics of fatigue in components such as vessels and piping, high temperature fatigue, special interacting aspects of fatigue and design as well as the problem of fatigue crack growth or propagation in pressure boundary components. A marked emphasis on new approaches involving the fracture mechanics evaluation of fatigue was apparent though most papers reported on efforts to simulate particular detrimental effects of service on specimens which in turn simulated the component or system.

In the area of fracture, a tendency toward advanced fracture mechanics evaluation for both the elastic and the elastic-plastic conditions was evident. The primary concern, of course, in studies of fracture is the avoidance of catastrophic failure of components of the primary pressure boundary whether it be a nozzle, a weld, piping, or primary component. A tendency observed by the author was the use of computer analysis for analytical assessment of the potential for failure through fracture.

If there was one criticism that stands high in the area of mechanical properties, it was this tendency of many researchers, not just the university but industrial laboratory investigators as well, to rely on numerical analysis and computer simulations of systems. This is contrary to the original goals of the conference which sought to bring together the specialists in design, fabrication, materials, and system operation for a full interaction of real world problems. This criticism was repeated to the author more than once even though one of the invited speakers, Dr. Pedro Marcal of the United States, cautioned in the plenary session against over-dependence on computer modeling and simulation for evaluation of pressure vessel integrity, reliability, or anticipated service performance. He, a computer specialist, had observed the problem of over-emphasis on computer studies to the detriment of prototypical evaluation of the service performance of pressure components. His warning apparently is very timely and I believe the planning committee for the next in this series of international conferences, which is to be held in London in 1980, will be alert to maintaining a balance of papers based on theory and computer simulation versus those based on laboratory or prototypical tests of components to simulate the pressure service conditions.

The author was not able to attend some major components of the conference: namely, sessions on design, system analysis, and inspection and fabrication. From limited attendance, however, a disappointing aspect was noted in the very limited emphasis on materials, though this negative is probably offset to a degree by the insertion of important papers on nondestructive inspection and testing, a rapidly advancing science that is critical to the future reliability of pressure systems.

A series of panel discussions were held on special subjects of advanced technology. These included a panel on design criteria of boiler and pressure vessels in different countries, that is, giving different national viewpoints or codes, a panel on elastic-plastic fracture mechanics (and here the emphasis was overwhelmingly based on the computer), and a third on the application of electron beam welding to pressure vessel technology techniques which has advanced significantly in recent years.

The author contributed to a post-conference lecture on materials research to support reliable nuclear power in the United States. This was based on his experience in heading a panel within the Federal Government to identify materials research and development needs to support several alternative nuclear systems. A companion paper also given at the University of Tokyo by Professor D. K. G. Latzko of the Netherlands reviewed critical energy problems in the near term.

NATIONAL RESEARCH INSTITUTE FOR METALS

K. O. Bowman

I visited the Creep Testing Division of the National Research Institute for Metals to acquire some creep data for the Metals and Ceramics Division of the Oak Ridge National Laboratory. The Metals and Ceramics Division is most interested in collecting information on materials related to nuclear reactors and steam generators.

Materials research is relatively new in Japan since industrialization came much later than that of Europe or the United States. To overcome any lag and to demonstrate Japan's leadership in materials testing, the National Institute for Metals was formed in 1961. The Creep Testing Division is one of three divisions that make up the Strength Group of the Institute. The remaining two are the Materials Strength Division and the Fatigue Testing Division.

The Creep Testing Division began large scale creep testing in 1965 with emphasis being placed on materials used in elevated temperature applications. At present, the creep properties of about 40 materials are being investigated (Table 1). Some tests are designed to last 100,000 hours (11.4 years); the longest test now in progress exceeds 6½ years. They have 1100 single-specimen creep machines and 450 multi-specimen creep machines (up to 18 specimens) making this one of the largest creep testing installations in the world. The Division has been supplying the results of these experiments in a publication "NRIM Creep Data Sheets" to about 160 installations throughout the world.

The materials testing program at the Creep Testing Division is directed by the Committee on Creep of the Iron and Steel Institute of Japan. This committee specifies material, product form, heat treatment and test conditions such as stress, temperature, and environment.

I was delighted to find that Dr. Yoshimura, Head of the Creep Testing Division, and his coworkers are applying statistical methodology to creep data. For example, they wish to predict stresses and temperatures that will cause rupture in 100,000 hours using results from tests that have lasted at most 60,000 hours. As they accumulate data from year to year, they compare the new results with those predicted by earlier models. However, they have difficulty in predicting these long time results. Heats of the same material from different manufacturers introduced a wide variation in the data and hence add a large measure of uncertainty to the predicted values. Unfortunately, they say they do not have the time nor the machines to replicate.

At present they are using linear and quadratic polynomials in conjunction with several time-temperature parameters (e.g., Larson-Miller). The maximum effective degree of polynomial is cubic; higher degrees were relatively ineffective. In some cases segmentwise regression fits the data better than a single polynomial. In general they find it reasonable to assume normally distributed residuals. When treating stress-rupture data, the logarithms of both rupture life and stress were used.

In a joint research effort with the Japan Atomic Energy Research Institute, the Creep Testing Division is studying the creep properties of SUS 316 Stainless Steel using both smooth and notched specimens. This material is to be used for the reactor vessel in their fast breeder reactor program. Specific conclusions which were mentioned include:

1) In the creep tests of two different heats, the minimum creep rate was higher for one than the other at 500° and 550°C, but this tendency was reversed at 600°C;

2) Nitrogen and niobium alloying elements are effective in increasing rupture strength;

3) The rupture life of weld specimens is about one order of magnitude lower than the base metals at 600°C;

4) All specimens tested exhibited good ductility; and

5) Creep properties of all heats met the criteria of ASME Boiler and Pressure Vessel Code, Section VIII.

Mr. Kurihara at the Computer Center of the Institute is initiating the application of the principles of multivariate analysis in his work with foundry industries. For example he expresses the pinhole problems in spheroidal graphite cast iron by a diagnostic model and applies factor analysis to pick out the principal components as the pinhole formation. He succeeeded in reducing 30 factors to 7 factors (retention time between molding and pouring, temperature, speed, etc.) as principal causes for the formation of pinholes in the casting process. He further applied the discriminant function method to these results and reduced the factors to three. His research is useful in the automatic fabrication foundry process as it finds causes of other casting defects. Mr. Kurihara is advocating the use of this method along with a high speed computer for quality control application in the automatic foundry process. Also he has written a simulation program to find the most economical steps for the operational procedures.

Dr. Yoshimura, his coworkers and Mr. Kurihara are self-taught statisticians. There are no statistics departments at Japanese Universities equivalent to those in United States universities. Consequently, Japanese statisticians fall into two distinct groups: (1) those in the mathematics departments under the Faculty of Sciences, and (2) those under the Faculty of Engineering such as Information Sciences, Computing, etc. The former is interested in the theoretical statistics oriented towards mathematics and the latter is more interested in applied statistical methodology. Since there are no statistics departments, very few persons are formally educated in statistical theory and methods. I consider this the major weakness of the Japanese statistical community.

TABLE 1

MATERIAL FOR PREPARING THE NRIM CREEP DATA SHEETS

Material	Use
Plates	
0.25C, Si-killed 1¼Mn–½Mo	Boiler & pressure vessel
Weldable, 0.15C 1Cr–½Mo 1¼Cr–½Mo 2¼Cr–1Mo, NT 2¼Cr–1Mo, QT	Pressure vessel
304 316	Nuclear reactor vessel
Tubes	
0.2C, Si-killed ½Mo ½Cr–½Mo 1Cr–½Mo 1¼Cr–½Mo–Si 2¼Cr–1Mo 5Cr–½Mo 9Cr–1Mo 304H 316H 321H 347H	*Boiler & heat exchanger*
Forgings & Bars	
1Cr–1Mo–¼V	Steam turbine rotor
13Cr–0.1C–low Si 12Cr–Mo–W.V.	Steam turbine blade
316	Bar
Castings	
1Cr–1Mo–¼V	Turbine casing
HK40 HP	Centrifugally cast reformer tube
HH–II	Chemical plant
Heat Resisting Alloys	
A286	Gas turbine disc
Incolov 800	Chemical plant
S590 N155 U500 Inconel 700 Inconel 713C X45	Gas turbine blade

STATISTICS RESEARCH AT CHIBA UNIVERSITY

K. O. Bowman

I found Chiba University to be somewhat different from other universities, as the research in statistics is carried out by different departments of the university. There are, however, many cooperative efforts between the departments which makes the statistics research more visible than that of some of the other universities I have visited. I met with a group of about 10 faculty members and graduate students from the various departments and they discussed their interests and told me of their ongoing research.

Dr. A. Asai, Professor of Statistics of the Mathematics Department of the Faculty of Sciences, is involved with the application of multivariate analysis in sample surveys and is making an effort to reduce the load of surveying. For example, suppose there are 12 questions and 3 sampling groups; if we design the survey and ask two-thirds of the questions to each group, the surveying effort and cost could be reduced drastically. In actual surveying they have found that some of the basic questions must be answered by the total sampling group, so they have developed a new design which accommodates this requirement and has a minimum variance. Their results showed that new estimators are not significantly different from estimators using the complete design. Now they are trying to solve the problems which are arising from using this new design experimenting with Monte Carlo simulation. Asai is also interested in medical applications of multivariate analysis. The patients with curvature of the backbone must currently be subjected to multiple X-rays at any one time to get the whole picture of the degree and place of abnormality of the spine. The danger is overexposure to radiation. Asai's method, which is under development, will use one picture with 3 dimensional contours and from this it will be possible to estimate the degree and location of curvature, thus eliminating multiple exposure to X-ray at any one time and the possibility of radiation build-up.

Assistant Professor H. Yanai, in the Psychology Department, Faculty of Humanity, spent four months from January to April of this year in India studying with C. R. Rao. His main research is formulating the generalized coefficient of determination (G.C.D.) using the projection operator. He has proved that coefficient of determination such as correlation ratio, squared multiple correlation and Mahalanobis generalized distance are represented as special cases of G.C.D. He is also interested in the best selection of variables when regression analysis or multivariate analysis is applied.

Dr. Y. Taga, Professor of Information Science of the Faculty of Engineering, is interested in the problems of optimum sampling systems, specifically: (1) optimum stratification in univariate and multivariate cases; (2) empirical stratification and optimum classification rule with specified mean vector and covariance matrix. For optimum stratification of the univariate case he derived weighted mean and minimum variances for the case of interval stratification with proportional allocation and Neyman allocation. For the multivariate case, he investigated proportional allocation. In the case of optimum classification, H. Chernoff of the United States originally developed it for the univariate case, and Taga extended it to the multivariate case.

Mr. Taguri, Lecturer of the Mathematics Department of the Faculty of Science, is interested in computer application and is working on the use of general non-linear programming algorithms to the determination of the optimum stratification points and minimum variances, which is related to Professor Taga's early research, but mainly he is interested in applicable optimum stratification. Mr. Taguri is investigating relations between sample sizes and the number of strata for the models considered. He is also considering the robustness and efficiency problems of the models. His other major interest related to computer applications is the graphical representation

of correlation analysis and the computer system for kidney transplants. Recently the latter has given great hope to many ailing kidney patients all over Japan as he is working with the medical school of Chiba University and developing a data bank of possible kidney donors and potential recipients. With all the necessary information the donor and potential recipient can be matched in a short period. At present, almost all the patients are receiving kidneys from their close relatives.

Mr. J. Nakagami, Assistant in Statistics of the Mathematics Department, is interested in the dynamic programming of inventory problems. He developed optimal inventory policy for the ordering of the production of seasonal style-goods in anticipation of the actual demand in the future.

Mr. M. Yasuda, Lecturer of the Faculty of the General Education of Science, is interested in the continuous time Markov decision process; in particular he is trying to solve the replacement problem related to systems failure. For example, if there are two systems, acceptable and non-acceptable, and this state could proceed only in one direction, he is trying to find a distribution of probability of this transition.

The group is now considering applying the stratification methods to Monte Carlo simulation. If they develop such a program it will save tremendous computing time for some Monte Carlo simulations. To sum it up, in Chiba University the research in statistics is generally in the fields of sampling theory and multivariate analysis both of which are applicable to real problems.

A CHANGE OF PACE RECOMMENDATION FOR VISITING SCIENTISTS – THE MUSEUM OF MARITIME SCIENCE, TOKYO

M. A. Bertin and E. Mohri

No one who has lived in, visited, read about, or even looked at a map of Japan is surprised about the importance of the sea to the island dwellers, their economic structure, diet, recreational interests, in fact total life style. Strangely enough, until relatively recently there was little movement or exploration on the part of seafaring Japanese beyond the coastal waters, and aside from travel to China and Korea, most of the contacts were by navigators from other countries. From this meager beginning the Japanese have sprung into the nautical arena through a series of giant strides. Their oil tankers, freighters, and fishing fleets may be found in almost every corner of the world; their cruise ships and pleasure craft cross the seas in a steady stream; their ferries, from lumbering ancients to modern hydrofoils, jammed with commuters, travelers, tourists, and those who simply want to get away from land for a brief spell, connect countless parts and islands. Japanese shipyards are the most automated and advanced in the world and unbelievably huge tankers are turned out in record time. Small wonder then that the Museum of Maritime Science is unique, reflecting the pervasive concern of the Japanese for the maintenance and stability of an existence which is so dependent upon the oceans and free access to them.

People approaching Haneda Airport from Tokyo, gazing seaward, will be curious about what appears to be a huge passenger ship with an enormous mast, looming on the near horizon in gleaming white. Unfortunately, from the highway one does not get close enough to recognize that what appears to be a titanic is in reality an enormous museum which performs an outstanding feat in tracing the history of the maritime world from earliest time to the present, displaying a true treasure-trove of ship models and components, providing a series of realistically animated exhibits portraying all facets of history, engineering, industry, and economy, certain to engage the attention of scientist, child, housewife or whomever. It is a truly G-rated show, fascinating for every member of the family as well as a must for those interested in the maritime sciences. Though the appeal is wide, there is little doubt that the primary target of the planners was the Japanese youth, hoping to create an understanding of the sea and its influence on culture and economics among those who will "carry the responsibilities of the next generation." The attractiveness of the museum is not, however, limited to its educational features. There are restaurants, a rest house, a 90 meter high observation tower, an ice skating rink in the winter, and two huge swimming pools, one of which flows in a circular fashion carrying swimmers along in a gentle current. Getting to the museum is only a slight bother, and part of the fun. One can drive, take a subway which connects with the museum bus, or best of all catch the museum boat which plows through the harbor providing views of ships and shore installations.

Our host for the visit to the museum was its Principal Director, Masao Yamashita, an engaging and knowledgeable man who obviously applies all of his vast energy and talent towards bettering the museum. He traced its history and explained that the museum operates independently of government funds or control, being wholly supported by the Japanese Foundation for the Promotion of Maritime Science (whose chief source of income comes from the Japan Shipbuilding Industry Foundation) and the fees derived from the relatively minor admission charges. Listening to the Director's plans for the future one must share his enthusiasm about opening new vistas for the youth of Japan, making clear the international character of the seas and the tie to industry, science, culture, and every day life.

Thus it can be said that among the many accomplishments of Japan, the Museum is dedicated to preserving the past, living in the present, and looking to the future. Located at the doorway to Tokyo Bay, it is a new symbol of maritime Japan, commanding a panoramic view of the city's skyscrapers, Mt. Fuji in the distance, transportation freeways, surrounding wharves, the current and soon-to-be-opened international airports, and the Pacific Ocean. As stated earlier, the building is in the shape of a 60,000 ton passenger ship, a model sparked by the abandoned hope of acquiring the Queen Elizabeth, a design enhanced in its distinctiveness by the surroundings, developed to foster an enlightened interest in things maritime. It bears repeating that the museum was established to provide and preserve an encyclopedic center of maritime affairs, dedicated to encouraging a deepening understanding and recognition of the contributions of the sea and ships to the cultural and economic development of the country. Since Japan heretofore had no background information concerning the preservation of historical treasures stored in museums such as in the western world, the planning group thought it timely that such an undertaking should be pursued. Thus a study team visited Europe, the United States and other countries of the world to research major museums. As stated earlier, an additional function of the museum aims at stimulating the interests and educating the young of Japan in the importance to the nation of the shipbuilding industry, both economically and internationally. The museum concentrates on a revolutionary "learn while you play" display method designed especially for elementary and junior high school students but attractive to all ages. General displays are housed on various decks reached by climbing stairways as if on a real ship.

"What do ships mean to man?" Visitors are first introduced to Symbol Hall, which stimulates a quest for answers in the minds of the viewers. This initial exposure reflects the direction of the museum and provides a capsule concept of its essence. An ingeniously illuminated map of the world displays, in animated fashion, the maritime linkages among the oceans of the earth. A multicolored display panel of exports and imports accents the importance of ships and the sea to the economic life of Japan and its interdependence with the world.

One sees large screened audio/visual displays utilizing colorful multiprograms; models of container ships, oil tankers, cargo-passenger ships, passenger ships, icebreakers; a layout of a shipyard showing the shipbuilding process from the raw material to a completed ship; a demonstration of the principles of ships, speed and shape of waves, and wave-making resistance; life-sized examples of types of engines used for ships ranging from small diesels to gas turbines; antipollution devices, etc., all exhibited on several decks. Also included in the general display is an area devoted to ships of the future: hovercraft using a new propulsion method, an MHD ship run electromagnetically, and a nuclear-powered commercial ship able to travel long distances at high speeds without refueling.

For those buffs whose special interest is ship history, the second deck presents a chronological display of ships illustrated by painted pictures and lifelike models from ancient Egyptian, Greek and Roman periods through the colonial times to modern day marine transportation. Models represented include the Santa Maria, the Victory, which joined in the Trafalgar sea battle, the tea clipper Cutty Sark and the "goza bune" Taiko Maru, the lacquered-top luxury boat of the fuedal Lord Hosokawa. Additional models are the Kanko Maru, the first steam-engine warship of the Japanese Navy dating from the end of the Tokugawa era; the world's largest battleship, the Yamato; the Kanrin Maru, the first Japanese ship to cross the Pacific. The model exhibit covers the gamut from warships, self-defense ships, fishing boats, marine safety boats, and seafaring and leisure activity boats. The whole aspect of modern sea transportation which supports the daily life of Japan and the world economy and influences future prospects is shown. The display is divided into world trade and marine transportation, sea transport in Japan and commercial fleets, coastal transportation activities, and the future of marine transportation.

Visitors to this floor are directed past a small round auditorium representing an engine room of a ship. This is the teaching room. Installed here are push button type machines containing questions and answers based on the exhibit. These can be operated by the visitors, especially the young, for self quizzing. Answers are displayed on a large screen, and automatic programs are performed according to a given scenario. These programs can also be revised for visitors upon request. This "engine room" is convertible for use as a discussion and meeting room as well as a visual aid room.

The underground display room features another area of world concern in exploring the use and resources of the ocean. The displays here are divided into ocean floor and submarine and sea surface. Shown are submarine oil field excavation devices, robot ships, submarine research bases and deep-sea working vessels, undersea ranches, fish breeding places, seadromes, marine and seaside cites, etc.

Up on the sixth deck is the bridge equipped with all the features of a real ship bridge. Here youngsters, and adults also, can simulate steering a ship from Tokyo to San Francisco while watching the screen before them. Another delightful exhibit is the navigation corner where visitors can navigate radio controlled models of passenger and cargo ships and patrol boats in a large basin of water 12 meters in diameter.

The museum also offers numerous educational facilities such as a 450-seat auditorium with portholes protruding on each side wall, classrooms and numerous small meeting rooms, and a library containing a collection of books and materials geared to the sea and ships.

For those of us who have been involved in planning for the design of living space aboard ships, the crew quarters of the future appear both revolutionary and a revelation, with ample area for luxurious living beyond present concepts.

An extremely attractive feature of the museum is the emphasis upon moving displays, providing the viewer with an animated presentation of a real world experience. Thus the primary theme of the museum appears to be to provide an action environment which stimulates, educates, and entertains. It is in the highest tradition of making history, economics, and science as palatable to absorb as possible.

KANAZAWA, A NATIONAL UNIVERSITY ON THE RUGGED HOKURIKU COAST

Morton A. Bertin

The City of Kanazawa was blessed with an absence of World War II bombing which devastated so many Japanese cities. For this reason today it suffers, or charms, depending upon your outlook, by being a good sized metropolis (about 300,000) of narrow and twisting streets. It is renowned as the home of the famous and much sought after Kutani pottery and no visitor is allowed to leave without having been exposed to the products and artistry of a Kutani factory. One is impressed by the fact that even more stunning than the pottery are the prices, especially of the older pieces on display. Kanazawa is situated on the Sea of Japan, across which the frigid winds from Siberia whirl unabated, in the winter dumping countless tons of snow on the Hokuriku Coast. At the time of our visit in the spring, warm clothing felt very much in order and there was a substantial residue of snow and ice in the shady areas.

The University is the product of the merging of several schools and today houses some 6000 students, 40 percent of whom come from the local area. The physical layout of the school is somewhat unique in that it was built on the grounds, and utilizes some of the buildings of an old castle. In fact, the ancient walls and moat are very much in evidence as are the Kenroku-Koen Gardens, among the most famous in Japan. For years these were considered to be a sort of extension of the campus, but the students were essentially "turned off" when a tariff or entrance fee was imposed. There are Faculties of Medical Science, Education, Law and Letters, Technology, Liberal Arts, Pharmacology, and two separate Psychology Departments, one in Law and Letters and the other in Education.

In the group in Law and Letters I met first with Jungi Komaki, an engineer turned psychologist, who has developed diverse interests including learning, vigilance, and human factors. In one of his earlier studies he investigated the facilitative effect of overlearning in discrimination learning in rats under three conditions. In the first (reversal) the animals were trained to discriminate black-white cards in the first problem and the reversal on the second. Next in a visual-visual condition, the first discrimination used striped cards and the second black-white. Finally, in the tactile-visual the rats were trained on smooth-rough plates and then on black-white cards. For each condition there were normal learning and overlearning groups. On condition one, the reversal, there was no difference between the control and the overtrained, but in both the other conditions the overtrained animals relearned in significantly less time.

In another study on the effect of self-checking on a vigilance task, Komaki used a pointer deflection amplitude as the signal. In one group the subjects were provided with performance feedback; in another group the subjects were required to self-check. A third group self-checked one half the exposures, and a control group received no feedback. The three feedback groups were superior to the controls in correctness of signal detection. The order of detection response speed was feedback, full self-check, half self-check, and control with all differences being significant.

In a study of dial arrangements, subjects monitored three display panels consisting of 16 dials with signals appearing on any four at one time. It was found that detection frequency was greatest in the top-right quadrant, next was the top-left, and worst bottom-left. These results were interpreted to reflect the particular reading habits of Japanese. It was found that the arrangement of the dials had a significant effect. It was also apparent that groups of adjoining dials were seen as units and were scanned as such.

Fujio Tanaka has an interest in psychological testing and has done extensive research using Rorschach on Japanese. He considers the scoring similar to that used in the United States. We discussed the status of clinical psychology in Japan, and Tanaka asserted that there are relatively few clinicians, most of them employed in child guidance clinics and hospitals. He is occasionally called upon to lecture in the medical school, but only infrequently. As stated above, much of his work has been with Rorschach and he has determined, on the basis of responses from 30 clinicians, that Klopfer's form-level rating system is most frequently used in Japan. He has also done research to investigate the effects of sodium amytal on Rorschach responses, finding that in general subjects tend to increase productivity, lessen reaction time, increase reaction to parts of the whole stimulus, and show less stereotyped thinking. In other studies he has looked into current problems methodology in Rorschach administration, Japanese opinions of Oedipus complex, and relationship between Rorschach responses and intelligence.

There are four psychologists in the Faculty of Education. Tad Tsushima, formerly a Fulbright Fellow at the University of Illinois, is primarily concerned with personality and clinical psychology, but his basic present interest is in the dynamics and treatment of human aggression. Specific areas which he has studied include hate, human destructiveness, death wish (a' la Freud), the fluidity of human nature and group therapy. In addition Tsushima has worked on stuttering and written several articles on Asian psychology.

In a study of the effects of partial reinforcement, Tsushima found that resistance to extinction was stronger for a group given 70 percent reward and 30 percent punishment than one given 100 percent reward. In part two of the same study Group I received 70 percent partial reinforcement and Group II was given 70 percent positive, 15 percent negative, and 15 percent non-reinforcement with no significant differences in learning. In another paper he traced the trends of psychotherapy in Japan from its beginnings rooted in Buddhism, Yoga, Chinese philosophy, Bushido training, and Shinto through to its baptism "by the western medical and psychological sciences." It appears that modern psychotherapy and counseling were rooted in the German school but that the influence of the Americans has been most pronounced in recent years. Tsushima reviewed the various approaches and analyzed the relationship between them and the unique aspects and problems of Japanese society. In joint research with his wife, Yukiko Tsushima, he has carried out studies related to stress and anxiety. In one, using college students, they attempted to determine the relationship between examination failure and anxiety inventory scores. There were success, failure, and control groups without significant differences emerging on the anxiety tests. In a related study the problem was to measure changes in anxiety scores from pre-stress to post-stress for groups high and low in level of anxiety. No differences emerged in the anxiety tests but trends did appear which indicated that the high anxiety group decreased more than the low and their variances were higher. They also produced a version of the Cattell Anxiety Scale, standardized for Japanese use.

Shoei Kaneko is primarily interested in intellectual development of children. He has carried out studies on intellectual acceleration of elementary school children, analysis of mathematical ability, analysis of the development of children's abilities according to their achievement scores, language and cognitive development, e.g., verbal mediational processes in children's thinking.

Isao Sato is a social psychologist who maintains an interest in the social psychology of education as well as a concern with cognitive processes and cognitive orientation, expressivity, and perception. He has also conducted some research with Rorschach including a study on the effects of drugs and one on Rorschach performance under sensory deprivation. In perceptual research he has carried out a study on the stereo-kinetic effect using circles which were turned on the front-parallel plane to the subjects. He found that the depth effect increased with an increase in the off-set and that a greater depth effect occurred with monocular than with binocular viewing. Also, spontaneous reversals of the depth occurred with most of the figures.

Masao Ohta is also a social psychologist who has worked on problems of school curricula, training, and career planning. He has written on such items as class quotas and competition ratios for high school admissions. In this regard he has looked into how students apply on the basis of quotas and the relationship between the number of students applying at each point in time and how this changes in relation to the quota established at the time. Also, in order to explore the change of selected courses, he surveyed courses preferred by students in

lower secondary schools over time. In the course of our discussions we learned that in addition to the psychologists at the university, there are several others in various institutes and departments working with deaf, mentally retarded, those with speech difficulties, and other handicapped.

TWO MARINE ESTABLISHMENTS ON THE MIURA PENINSULA

Morton A. Bertin

Japanese newspapers recently carried an article announcing the distribution of scientific research grants by the Ministry of Education, and one of ¥ 3.6 million (about $13,000) attracted our special attention. It was to Dr. Yasuo Suyehiro, Professor Emeritus of the University of Tokyo and presently Director of the Keikyu Aburatsubo Marine Park Aquarium. The reason for our interest was two-fold: we had a previous connection with Dr. Suyehiro (known in Japan as the "fish professor") through Dr. Eugenie Clark, who had carried out some of her work on sharks at the Aquarium and is a Special Foreign Advisor there. Also the area of research being funded was intriguing, a study of the electrocardiograms and electroencephalograms of certain fish to establish a relationship between them and impending seismic activity. In the inimitable style of journalists everywhere one newspaper titled its article announcing the award as "Japanese study catfish-earthquake link," which puts it as succinctly as possible.

The main aquarium building is an attractive circular edifice well situated near the tip of the Miura Peninsular, about one and a half hours by train from Tokyo. We met with Dr. Suyehiro and Hiroshi Kabasawa, Assistant Curator, who later acted as our guide in touring the facility, not only from the tourist view point but also from behind the scenes. Dr. Suyehiro told us of the history of the aquarium, putting it in the perspective of the aquaria of Japan. Apparently the first was built during the Ueno Grand Exhibition in 1890 and at present there are over 100 in the country. The Aburatsubo Aquarium was opened to the public in 1968, its construction and subsequent upkeep assumed by the Keihin Kyuko Railroad as a milestone commemorating the 70th anniversary of the founding of the company. At the time of our visit the aquarium was crowded with interested throngs of Japanese sightseers of diversified ages, mostly young children who appeared fascinated by the colorful and active displays. The primary impression is one of movement accentuated by variations in lighting and hue. Before going into the scientific aspects, I would like to touch briefly on the sights and sounds of the aquarium.

From independent sources I have learned that the aquarium is one of the leading in the country, with but a single other competitor for top honors, a fact which is readily believable to those who visit. The inner structure is circular, two-storied, and seemingly dedicated to making marine education as acceptable and easily understood as possible, regardless of age or background. The outstanding, or at least most overpowering display is the circular tank which covers the entire wall of the upper story, wherein are numerous species of sea life moving colorfully in a kaleidescope of light and speed as though impelled by some force of perpetual motion. It appears to be a true reflection of life in the sea, with surface swimmers rarely coming into contact with those who scavenge the sea floor. During feeding time a human mermaid enters the tank and adds a touch of unique, sometimes humorous activity to the scene. Here one has all of the benefits of an inside-out display, being surrounded by the dynamic panorama of the sea.

The lower deck houses the equally dramatic though somewhat more informative and educational components of the aquarium. Viewers move along at their own pace, past displays showing all manner of sea life categorized by Japanese and English captions according to certain particular variables. One passes sea vaults wherein the inhabitants are classed into types: fresh water, brackish water, marine fish, deep sea fish, with pressure adjusted to match, protective coloring fish, with changing environment as graphic evidence, poisonous fish, ancient fish, cold sea water animals, with temperature rigidly maintained at proper levels, luminous marine

fish, blind cave fish, fish in armor, sleeping fish, symbiotic relations, parasitic fish, fish camouflage, electric fish, sexual dimorphism, nocturnal fish, and several other completely fascinating groupings.

As stated earlier, it is a place of constant motion on the part of the viewers as well as those being viewed. Projected on the dome-like ceiling are frequent moving picture displays of marine activity shown several times normal size, like something out of science fiction. Periodically there is also a live fish show which portrays a fish acrobat, conditioned to pass through round loops and avoid square ones; traffic signs of the fish kingdom, where the fish avoid the red traffic signal and move to the green; fish musician, trained to respond differentially to different tones; fish mathematician, wherein calculations are simulated with the fish in fact responding to ultraviolet rays not discriminable by the audience; fish flag raising which utilizes the sense of smell; and finally something designated the fish magician, which remains something of a mystery, except that the performer appeared to disappear during a storm and reappear when it passed.

In a sense the tour was the appetizer before the main course, that is visiting the laboratories and discussing the research, some completed and some in process. Naturally, the laboratories are geared for the on-going work, with particular emphasis on developing a system to monitor the physiological variables while the fish are free-swimming. They have implanted electrodes into the brains of catfish and have managed to produce an oscilloscope display of the activity. I discussed the plans for data collection and record keeping, and it appears reasonable to anticipate that there will have to be some computerized system. Another laboratory is more pedestrian in function, monitoring the quality of the water from the research and other tanks. The water is used over and over, going through a constant purification process. In another laboratory a behavioral study is underway using elephant or snout fish, a small, impossible-looking shy little creature, which peeked curiously out at us from its pipe shaped refuge, waiting for us to move away before venturing out. We visited the implant room where surgical procedures are done, it requiring about ten minutes to complete an implant. Finally, there are training rooms where the fish are conditioned to someday act as stars in the performances described earlier.

The research undertaken by Dr. Suyehiro and his associates has been prolific and diversified, though there is a certain continuity. It is not surprising, considering Dr. Suyehiro's active background of academic research that he wasted no time getting started. Although the aquarium opened in the spring of 1968, several research projects were completed the very first year of operation. Most of these early experiments dealt with applied problems encountered in the operation of an aquarium, ranging from control of parasites to determination of whether the flow in the circular tank should be clockwise or counterclockwise. However, it was also in this first year that Suyehiro completed a review of all information and reports of unusual behavior of fish prior to earthquakes, in which he concluded that there was sufficient evidence of an unusual change of activity worthy of further investigation. At that point he raised the possibility that through the keener sense of smell, aquatic animals are able to detect a chemical change occurring in the earth's crust prior to seismic activity.

As might be expected, there have been periodic searches for significant fish activity prior to earthquakes. Suyehiro has graphed the level of the catch after seismic occurrences and has found in several cases that there was a significant increase in the amount of fish taken during such periods. Also, a study in inland waters showed that fresh water fish vocalized prior to a shock and that catfish left the river and entered the sea.

In another study they replicated earlier work on fresh water fish using salt water species to determine that they could distinguish ultra-violet rays in a conditioning experiment. In work on anesthesizing fish using Ethyl P-Aminobenzoate, it was found that the time to anesthesize could be expressed by means of a linear expansion varying with species and size. In an auditory discrimination task the fish learned to discriminate between a reed organ and a drum in relatively short order. In a study on the effects of velocity and light level, it was found that cruising speed of yellow tails remained relatively constant regardless of current, but under high light the fish speeded up significantly and conversely they slowed down under low light levels.

Though not as well known as the problems of Australia with its Crown of Thorns starfish, Japan has had difficulties for several years with starfish threatening their lucrative clam culture. Dr. Suyehiro had been a member of the group which studied the Australian problem on site, and he returned to tackle the elimination of local

starfish. The approaches developed in Australia were not practical nor useful in Japan and working with Kabasawa he discovered a relatively inexpensive and effective way of destroying the threat. After a series of experiments with different devices and chemical mixtures, they found that the best results were obtained by using a net-like vinyl pipe soaked in a paste mixture of 20% copper sulphate and gel with 2% ammonium sulphamate and gel. Because the mixture does not distribute far from the source, there is no threat to fish or coral 10cm or more away from the pipe, but it is very deadly to the starfish and has proven to be effective.

In a series of studies the conclusion emerged that several weak fish groups banded together to seek protection from their enemies. Another report considers the value of sodium chlorite in water to eliminate small plants suspended therein. In an attempt to control the activities of starfish plaguing the scallop culture of northern Japan, the group applied the methods described earlier with satisfactory results. Finally, a series of studies investigating respiration rates in sharks was carried out, some jointly with Eugenie Clark (see Volume 1, Number 1, *ONR Tokyo Scientific Bulletin*).

This establishment is highly recommended for a family visit and it should be particularly illuminating for marine biologists. As stated earlier, the group is active in research and dynamic in the operation of the aquarium facility itself. We found it stimulating and informative being both scientific and otherwise entertaining.

Within a few minutes from the aquarium is the Misaki Marine Biological Station, which is a government institution and a laboratory of the University of Tokyo Faculty of Science. Founded in 1887, it is situated on land which formerly was the site of the Aria Castle, occupied for centuries by the Miura clan. It is replete with romantic history, and the struggles and final mass harakiri of the besieged remnants of the clan are still celebrated annually by the locals. It is of interest that the station grounds occasionally divulge information in the form of pottery and arrowheads of an ancient tribe which dwelt there in prehistoric times. Of more pertinence to the present scientists who use the station is the fact that the location is particularly well situated in the quest for collecting numerous species of sea life, particularly the tropical plankton which are blown in by strong winds from the Kuroshio current from the south. Furthermore, Misaki contains a variety of habitata and formations which house a rich collection of marine animals and plants. The deep sea line is relatively close off shore, which likewise enhances the potential for acquiring various forms.

We met with Dr. Hideshi Kobayashi who spoke of the work and gave us a tour of the laboratories and facilities. The station is not geared for tourists and aims at developing well conceived research programs. It is one of 19 such stations, bound together under a loose consortium under a Council of Japanese National Marine and Inland Water Biological Stations. All belong to the national university system and are also used as instructional laboratories for students. At the time of our visit there were two foreign scientists working on projects and we learned that the policy is to welcome out-of-the-country scholars.

The primary research areas fall into fairly specific categories: experimental and biochemical embryology mostly on sea urchins; comparative endocrinology in the lower vertebrates; echinoderm ecology and taxonomy; and histology, especially wound healing in animals. Reports covering the work is published in the "Contributions from the Misaki Marine Biological Station," which is available to overseas groups on an exchange set-up. Table I contains titles of the reports from the Volume for 1975.

As stated earlier, the laboratories are functionally organized and appeared to be well equipped with an electron and a scanning electron microscope. Originally there had also been a small aquarium but at the time of our visit, there were but a few inhabitants of the deserted building. The station has a few boats for specimen collection, and is beautifully situated on high ground above what appears to be a sheltered inlet. Most of the staff reside on the grounds, separated from the hustle and noise of the town, quite an idyllic spot and conducive to quiet contemplation and undisturbed study.

Table I

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ONR TOKYO LIAISON SCIENTIST AWARDED HONORARY DOCTORATE

Morton A. Bertin

Dr. Leslie S. G. Kovasznay, a member of the ONR Tokyo scientific staff on leave from Johns Hopkins University was granted an Honorary Doctorate of Engineering by Nihon University on 5 July 1977. In a special ceremony to commemorate the event, Dr. Masaru Suzuki, President of the University, delivered the following citation:

"Dr. Leslie S. G. Kovasznay, Professor at The Johns Hopkins University, is well-known as a world-famous authority on aeronautics, fluid mechanics in particular, enjoying a high esteem in the scientific world as a scholar of noble character.

Dr. Kovasznay has for long devoted his energies to the development and advance of the science of fluid mechanics in Japan and has brought up a large number of Japanese researchers.

As far as this university is concerned, Dr. Kovasznay has imparted his profound and exhaustive knowledge to teachers and students through research guidance, special lectures, etc., on all occasions of his visits to Japan and thus he has rendered distinguished services for the promotion of education and research activities of this university.

Wherefore, in recognition of his splendid accomplishments and honors he rightfully deserves, the Degree of Doctor of Engineering *honoris causa* is hereby conferred."

Minister Thomas P. Shoesmith, Deputy Chief of Mission of the American Embassy, Tokyo, addressed the assemblage in the following words:

"As a representative of my government and of the American Community in Japan, it is a pleasure and a privilege for me to participate in these ceremonies bestowing such a high honor upon one of our countrymen, Professor Leslie Kovasznay.

For the past two years, Dr. Kovasznay, Professor of Aeronautics at Johns Hopkins University, has been a member of the American Embassy in Japan as a visiting scientist. This, however, has been only the most recent period in his long association with Japanese science. Over the years he has visited Japan at least six times, on each occasion meeting with his many friends and colleagues to exchange views on the current state of research in Japan and the United States. During 1965 and 1966, he spent 13 months as visiting professor at the University of Tokyo, teaching graduate students and giving numerous lectures at institutions of research and higher learning. His association with Nihon University is of similarly long duration, marked by an exceptionally close and mutually beneficial relationship with faculty and students. Indeed, Dr. Kovasznay has supervised the doctoral research of many members of the faculty of Nihon University, a role which he has also played with several graduate students from other universities. Not the least of Dr. Kovasznay's many contributions had been the guidance and advice he has given to numerous budding Japanese scientists in their scholastic careers as well as to their research efforts as young professsors.

Dr. Kovasznay has been an active participant in international meetings and seminars throughout the world. Several of these have been in Japan and have afforded him a continuing opportunity to maintain contacts with colleagues from many nations on their mutual interests.

Dr. Kovasznay is well known as a prodigious researcher in the field of aerodynamics and fluid flow, respected and admired for the generous spirit with which he has shared his knowledge and experience. For the past two years, Dr. Kovasznay has given unstintingly of his time, lecturing, supervising graduate research, assisting Japanese scientists to establish contacts in other parts of the world—especially in the United States—and acting as a highly skilled advisor on behalf of his Japanese colleagues in reviewing their experimentation.

As Americans, therefore, we take great pride that Nihon University has seen fit to bestow upon Professor Kovasznay this honorary degree, in recognition not only of his professional accomplishments, but also of the contributions he has made to Japanese science and to strengthening the bonds of friendship and mutual understanding between our two countries. We applaud both this high distinction and him who receives it."

Ichiro Tani, Professor Emeritus of Nihon University and the University of Tokyo, a member of the Japan Academy and a friend of long-standing of Dr. Kovasznay made the following congratulatory address:

"Today is an auspicious day called *taian* in Japanese. As one of the friends sharing the same specialty as Professor Leslie Kovasznay, I heartily congratulate him for being awarded the honorary degree of Nihon University on this auspicious day of old Japan.

Professor Kovasznay is of international fame in the science of fluid dynamics, particularly the turbulent motion of a fluid. Turbulence is the irregularly fluctuating motion of a fluid such as air or water. The smoke from a cigarette becomes turbulent high up the stream. Natural motions like the wind over the ground and the stream in a river are mostly turbulent. The air flow over an airplane wing is also turbulent in most cases. It is almost one hundred years since turbulence has been the subject of scientific study, although its progress was relatively slow, leaving many problems of importance still unanswered. This makes inevitably uncertain, for example, the forecast of weather, prediction of the performance of a new airplane, etc. Even from the practical viewpoint, therefore, it is highly desirable to obtain a correct understanding of turbulence. One of the reasons for making the understanding so difficult may be ascribed to the peculiar feature of turbulence that the fluctuations are not altogether random but contain some degree of coherence. In order to extract the coherent component out of the apparently random fluctuations, however, the classical mathematical analysis is almost useless, which yields only the process of deduction and induction. Instead, it turns out that the solution requires an abductive process based on the novel techniques of experimental observation. Professor Kovasznay is not only a world-famous pioneer in electronic measurements which are essential to the observation of turbulence, but he is also blessed with the unequaled originality in designing the pertinent experiments and synthesizing the results of the experiments. It is quite natural to find that the mechanism of turbulence phenomena has been disclosed step by step through the novel attempts of experimental investigations headed by Professor Kovasznay. This reminds me of the famous words of the American writer, Mark Twain, that everyone talks about the weather but no one does anything about it. It appears to me that "weather" may perhaps be replaced by "turbulence," and I firmly believe that the investigations of Professor Kovasznay may be evaluated as one of the rare achievements that really contributed something to turbulence.

As a scientist interested in fluid dynamics it is my greatest pleasure that the honorary degree is awarded to this outstanding professor of brilliant achievements. However, my pleasure does not remain single but is doubled, because Professor Kovasznay was the first Hungarian-born American friend to me, and I was the first Japanese friend living in Japan to Professor Kovasznay. Indeed, it gives me a keen pleasure that this long-lasting friendship is now colored by his glorious honor awarded here in Nihon University. Furthermore, my doubled pleasure becomes even tripled, since it may be adequate to interpret the honorary degree as having been presented by Nihon University on behalf of our country in recognition of his valuable contributions, particularly his kind guidance and stimulating advice given to the younger scientists of our country."

The commemorative lecture delivered by Kovasznay was entitled "Why Turbulence Research?" Following the ceremony, which was attended by about 300 friends, faculty, and students, Professor Kovasznay was honored at a reception tendered by the University. He departed a few days later on an official visit to the Peoples Republic of China and on to a Turbulence Symposium in Berlin, returning in early September to his position at Johns Hopkins. We at ONR Tokyo congratulate our colleague on the honor bestowed upon him.